HARVARD UNIVERSITY

LIBRARY

OF THE

Museum of Comparative Zoology

UNI
9124

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

MUS COMP ZOOL
LIBRARY
JUL 11 1980
HARVARD
UNIVERSITY

Host-relations of the Batfly *Megistopoda aranea* (Diptera: Streblidae) in Panamá

By

William L. Overal

Vol. 52, No. 1, pp. 1-20 June 27, 1980

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 1, pp. 1-20 June 27, 1980

Host-relations of the Batfly *Megistopoda aranea* (Diptera: Streblidae) in Panamá[1]

William L. Overal[2]

CONTENTS

Abstract 1
Introduction 1
Materials and Methods 2
Survey Results 5
Life Cycle of *Megistopoda aranea* 8
Behavior of *Megistopoda aranea* 12
Ecological Considerations 16
Summary 18
Resumen 18
Acknowledgments 19
Literature Cited 19

Abstract

Megistopoda aranea (Coquillett, 1899) is the most common insect ectoparasite of the frugivorous bat *Artibeus jamaicensis* (Chiroptera; Phyllostomatidae) in Panamá. This flightless batfly infests about 60% of individuals of this host species, whereas its occurence on other hosts is sporadic and probably accidental. When these flies are separated from hosts, they survive only 5-20 h. Normally, they never leave the host except when females pupiposit. Puparia are placed in the bat roost in the vicinity of the host, usually on a rough surface above the host. The pupal stadium lasts about 23 days under conditions resembling those in a bat roost. Newly emerged adults can curvive about 36 h before feeding. Copulation was observed to occur two days after emergence. The larval stages which are passed within the female's body total 10 days. Adults of both sexes lived for about two months on caged *A. jamaicensis*. The main source of mortality was host grooming.

M. aranea occupies the host's body fur and avoids the wing membranes. In choice arenas these batflies show a marked preference for rougher surfaces, behavior which is probably important for the maintenance of contact between batflies and their hosts. Increased locomotory activity was observed in response to sudden movements of air. In an "alert" posture the fly raises three legs while standing on its alternate legs. This often precedes a "procession" movement in which the animal moves sideways in an outward spiral on a horizontal surface. Host odor was not found to have attractiveness for *M. aranea,* although temperatures in the range of the host's skin temperature may be attractive.

Megistopoda aranea is probably restricted to *Artibeus jamaicensis* by ecological factors, such as roosting behavior of this host and colony size and stability, in addition to intrinsic factors, such as host odor or physiology.

Introduction

That a host organism and its obligate parasite constitute a unified system, linked by physiological, ecological and behavioral compatabilities, requires that answers to problems of maintenance of the parasitic relationship be sought in the biology of both the host and parasite. The present study seeks to determine how the association between the batfly *Megistopoda aranea*

[1] Contribution no. 1705 from the Department of Entomology, University of Kansas, Lawrence, Kansas 66045.

[2] Present address: Museu Paraense Emílio Goeldi, Caixa Postal 399, 66000 Belém, Pará, Brasil.

(Coquillett, 1899) and its principal host, the Jamaican Fruit-eating Bat, *Artibeus jamaicensis jamaicensis* Leach, is maintained. Aspects of this association which were investigated concern the life history, orientation behavior and occurrence of the batfly, the activities and habits of the host, and the co-existence of the host and parasite.

Like other species of the dipterous family Streblidae, *Megistopoda aranea* is an obligate, blood-sucking parasite of bats. It is reported in the Neotropical Region from Mexico to Brazil, Paraguay and Perú, and throughout the West Indies (Wenzel, 1970). Determination of this species from the United States (Stiles and Nolan, 1931: 658) refers to an accidental introduction or is in error because none of the hosts of *M. aranea* are resident in that country. The batfly has been frequently collected in Panamá and the Canal Zone (Wenzel et al., 1966), where the present study was conducted. Other specimens used in this investigation were collected in Costa Rica and Mexico.

Contributions to our knowledge of the life cycles and natural history of streblids have been made by Muir (1911), Jobling (1949), Ross (1961), and Wenzel et al. (1966). Immature stages have been discussed and figured by several authors (cf. Maa, 1971), and such findings are well summarized by Hennig (1952: 405). The biology of nycteribiid batflies is better known than that of streblids, primarily through the works of Rodhain and Bequaert (1916), Hase (1931), Schulz (1939), Ryberg (1947), Hurka (1964), Leong and Marshall (1968), and Marshall (1970*a*, 1970*b*). Aspects of hippoboscid biology relevant to this study have been presented by Coatney (1931), Bequaert (1953), and Hill (1963). Important questions pertaining to the adaptations and host-specificities of pupiparous Diptera have been raised and discussed by Theodor (1957), and Wenzel and Tipton (1966).

Taxonomic placement of *aranea* in the genus *Megistopoda* Macquart (1852: 332) was by Maa (1965), when the genus to which it had originally been assigned, *Pterellipsis* Coquillett (1899), was placed in synonymy. Both Maa (1965) and Wenzel et al. (1966) indicated that *aranea* may be a junior synonym of the type species of the genus, *Megistopoda pilatei* Macquart (1852). *Megistopoda desiderata* Speiser (1900) is a synonym of *M. aranea* (Coq.) (Aldrich, 1907). The morphology of *M. aranea* has been investigated by Jobling (1949: 316; 1952: 134) and Machado-Allison (1966: 70).

Megistopoda aranea was chosen for this study because of its relative abundance in Panamá and because of the high degree of host specificity indicated by collections (Wenzel et al., 1966). Host bats can be kept in the laboratory (Novick, 1960), and their dietary and roosting habits are known (Goodwin and Greenhall, 1961). The fly is flightless and can be handled without damage. It is easily located on a host due to its size, light tan color, and long hind legs. *Megistopoda aranea* is distinctive and not easily confused with other streblids. Even congeneric species may be distinguished under low magnification. Sexing is easily accomplished with etherized flies. The availability of natural colonies of infested *Artibeus jamaicensis* which could be observed directly permitted the formulation of hypotheses which could be tested with laboratory colonies of the host and parasite.

Materials and Methods

Field work was done in the Republic of Panamá and the Canal Zone during December, 1970, and January, June, July and August, 1971. Laboratory work was done at the field station of the Smithsonian Tropical Research Institute on

Barro Colorado Island in the Canal Zone and at the Department of Entomology of the University of Kansas.

Bats and batflies were caught in Panamá or the Canal Zone with the use of nets. Mist nets were employed in the manner illustrated by Greenhall and Paradiso (1968), usually being placed over streams, along forest trails, or under fruiting fig trees known to be attractive to *Artibeus* bats. Within caves or buildings containing bat roosts, hand nets were used. In either case bats were placed individually in paper bags for transport to the laboratory or before being etherized, to avoid the misassociation of their parasites. *Artibeus jamaicensis* has been reported as a carrier of rabies virus in Panamá (Constantine, 1970: 355; Keenan, pers. comm.). Because infected bats can transmit rabies to man, all bats were handled with gloves by personnel vaccinated with duck embryo rabies vaccine.

Batflies were removed with forceps from the bat or from the paper bag in which a bat was kept. Catching the flies by their hind legs did not appear to cripple them or affect their behavior. Live flies were kept on a host until use. Dead flies were preserved in 70% ethanol, and hosts were preserved in formalin for identification.

Bats used in experimental infestations were housed in shaded areas outside the laboratory on Barro Colorado Island, in cages of 0.6 cm wire mesh. Although the batflies could easily pass through this screening, this was not found to be a source of batfly losses since the flies remained in contact with a host and did not wander off. Cages were cylindrical, 60 cm high and 45 cm diameter, with a detachable bottom for convenience in cleaning. Generally, no more than 12 bats were kept in a cage of this size. A flight cage (10 m $\times$ 5 m $\times$ 3 m) with a concrete floor was used to house a colony of 155 bats.

The experimental bats, *A. jamaicensis* and other stenodermines, are frugivorous and can be maintained on diets of fruits and vitamin supplements. Fruits accepted by *A. jamaicensis* include bananas, figs, mangoes, melons and apples. These were peeled, sliced, and mixed with dried milk powder and vitamin syrup. Water was continuously available to the bats, but none was observed to drink. The environmental conditions under which the bats were kept varied more than did the conditions in bat roosts from which some bats were collected, but this did not appear to have a significant effect on the bats. The temperature varied from 16°C to 30°C and the relative humidity from 60% to saturation in a daily pattern (Fig. 1). Individual bats in the laboratory colony were marked by application of quick-drying paints to their hind claws which permitted identification from outside the cage.

In addition to laboratory colonies, natural colonies of *A. jamaicensis* were observed in their roosts for comparative purposes. These colonies were located in three abandoned bunkers in Ft. Kobbe, C.Z., in Chilibrillo Caves, Chilibre, Panamá, and in a culvert under Madden Forest Road, C.Z. Care was taken not to disrupt these colonies, and since individuals were not repeatedly observed, these bats were not banded or marked.

Collections were made of bats and their parasites at several localities in order to survey the geographic distribution of *M. aranea* in Panamá and its incidence and frequency of ocurrence on various hosts. Where possible, a sample of at least 25 *Artibeus jamaicensis* was taken at each locality in order to assess the effect of edaphic conditions on the host-parasite relationship. Those localities where this was possible are listed in Table 1 and mapped in Figure 2. Bats for experimental work were netted in June and July, 1971, at Balboa Heights, C.Z., under a fig tree

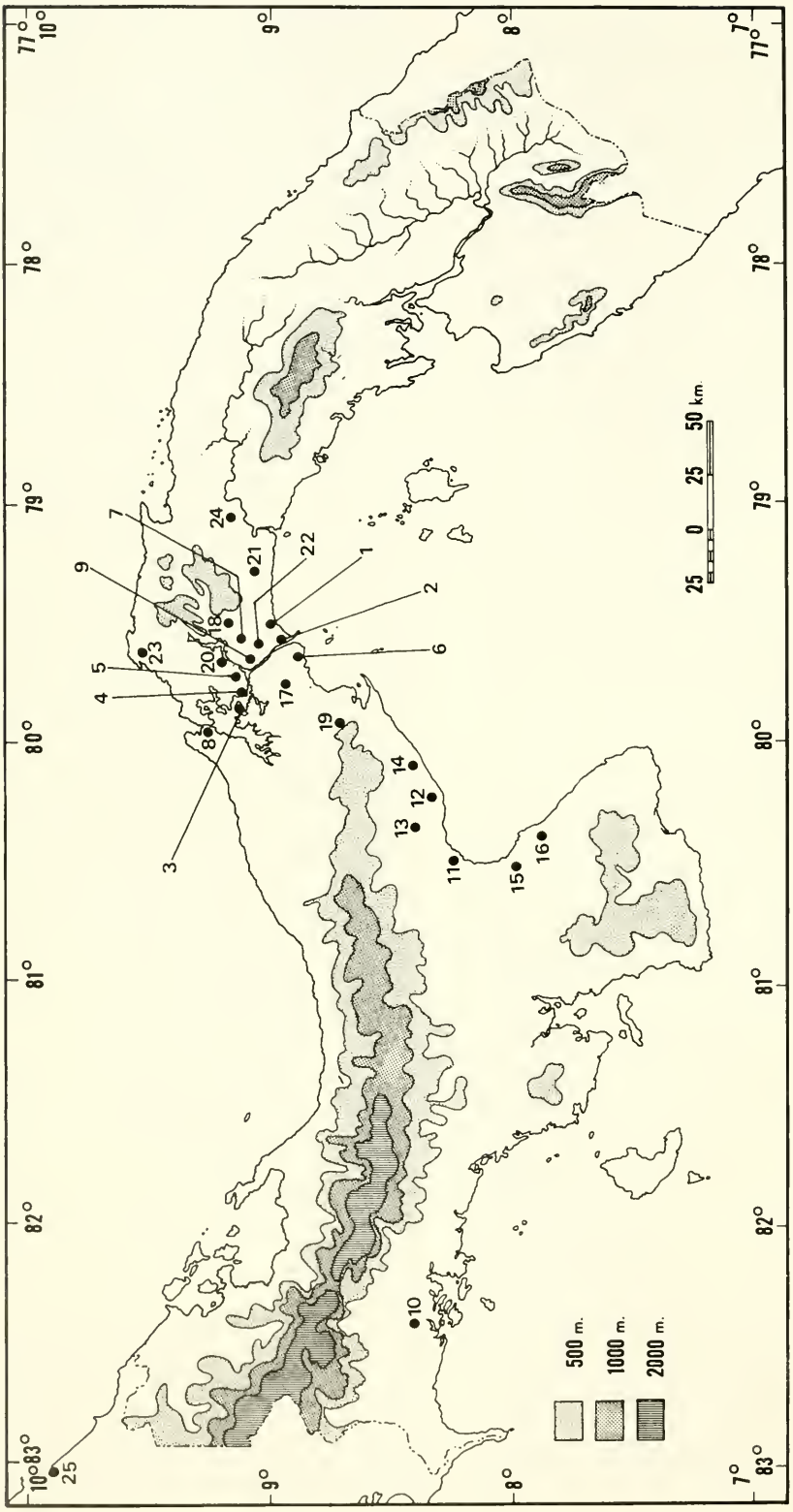


FIG. 1. Temperature and relative humidity in the outdoor bat cage on Barro Colorado Island where experimental animals were maintained; curves averaged over July and August, 1971.

near the railroad station, and at Summit Gardens (Botanical Park), C.Z. Voucher specimens have been deposited with the Museum at Kearney State College, Nebraska (Alcoholic Mammal Collection, Catalog Nos. 1246-1271) in the care of Dr. J. Farney, who verified identifications made in the field. Specimens of *M. aranea* used in this study have been given to the Snow Entomological Museum of the University of Kansas.

Specific techniques relating to the care and use of batflies in behavioral and physiological experiments are presented in the pertinent sections below. Statistical tests are as given by Sokal and Rohlf (1969).

Survey Results

Megistopoda aranea has been reported from a variety of hosts. Reports include *Phyllostomus* sp. (Stiles and Nolan, 1931: 658), *Artibeus yucatanicus* in Mexico (Hoffmann, 1953), *Artibeus planirostris polax* in British Guiana, *Artibeus planirostris trinitatis* in Trinidad and Tobago (Machado-Allison, 1966; Goodwin and

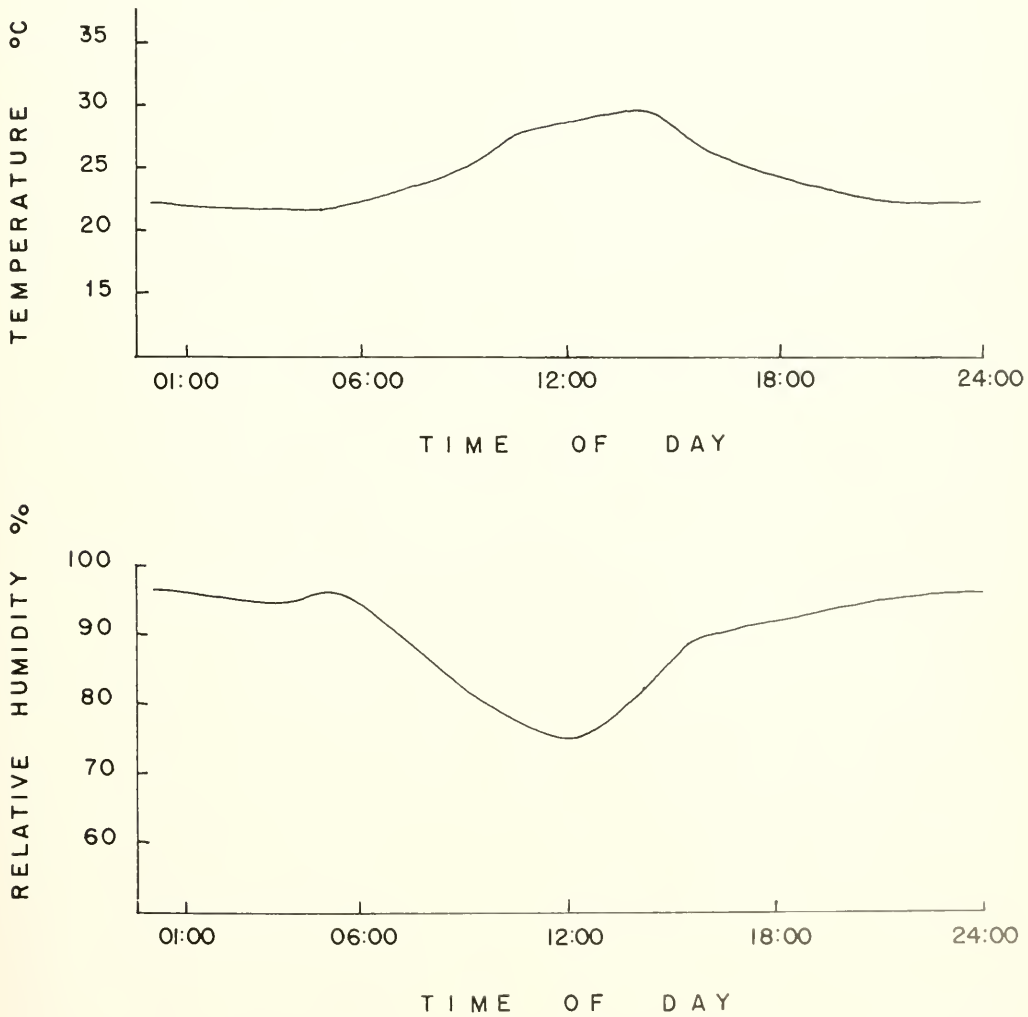


FIG. 2. Map of Panamá showing localities where bats and their parasites were collected. Place names and coordinates for these localities are given in Table 1.

Greenhall, 1961), *Artibeus jamaicensis parvipes* in Cuba (Matheson, 1928), *Sturnira ludovici* in Costa Rica (Tonn and Arnold, 1963), *Artibeus j. jamaicensis, A. literatus palmarum, Carollia perspicillata azteca, Desmodus rotundus murinus,* and *Phyllostomus discolor* in Panamá (Wenzel et al., 1966). The published host records are difficult to interpret because of the unsettled and specialized nature of bat taxonomy and because of the possibilities for errors in associating hosts and parasites during collecting or labeling. Wenzel et al. (1966) believe *Artibeus jamaicensis* and *A. literatus* are the primary hosts of *M. aranea* in Panamá, although *A. literatus,* as interpreted by them, may represent a species complex (Wenzel, pers. comm.).

Examination of collected lots of 14 bat species in Panamá revealed that *M. aranea* was apparently restricted to three species, *Artibeus jamaicensis, A. literatus,* and *Carollia perspicillata.* Figure 3 shows the percentage of each of these species which was infested with *M. aranea. Carollia perspicillata* is probably not a normal host of *M. aranea* because of its low frequency of parasitization and because no *C. perspicillata* had more than one individual of *M. aranea,* suggesting a random transfer. The status of *A. literatus* as a host of *M. aranea* is uncertain. *A. literatus* and *A. jamaicensis* have been netted in the same collection lot, suggesting that they may forage together, but they have not been observed to roost together. They do, however, share the same caves in Panamá, such as the Chilibrillo Caves, and the possibility that *M. aranea* on *A. literatus* may have dispersed, if only temporarily, from *A. jamaicensis* cannot be ruled out.

Of the several previously reported Panamanian hosts of *M. aranea,* only the vampire, *Desmodus rotundus,* was not adequately sampled. More than 200 vampire bats have subsequently been collected from the states of Veracruz, Oaxaca and Chiapas in Mexico, however, and *M.*

TABLE 1. Names and coordinates of localities mapped in Figure 2.

No.	Name	Coordinates[1]	Description
1	Ancon, C.Z.	8°57′N-79°34′W	under fig tree
2	Balboa Heights, C.Z.	8°57′N-79°34′W	under fig tree
3	Barro Colorado Is., C.Z.	9°09′N-79°51′W	forest clearing
4	Frijoles, C.Z.	9°10′N-79°49′W	forest trail
5	Gamboa, C.Z.	9°06′N-79°42′W	under fig tree
6	Ft. Kobbe, C.Z.	8°54′N-79°36′W	abandoned bunker
7	Madden Forest, C.Z.	9°05′N-79°39′W	forest clearing
8	Ft. Sherman, C.Z.	9°21′N-79°57′W	wet forest
9	Summit, C.Z.	9°03′N-79°40′W	Botanical Park
10	David, Chiriqui	8°26′N-82°26′W	near stream
11	Aguadulce, Cocle	8°14′N-80°33′W	forest near docks
12	Anton, Cocle	8°24′N-80°16′W	under fig tree
13	Penonome, Cocle	8°31′N-80°22′W	near Rio Zarati
14	Rio Hato, Cocle	8°22′N-80°16′W	near shore
15	Parita, Herrera	7°59′N-80°32′W	forest boundary
16	Los Santos, Herrera	7°45′N-80°21′W	under fig tree
17	Arraijan, Panamá	8°57′N-79°41′W	forest near C.Z.
18	Calzada Larga, Panamá	9°10′N-79°34′W	abandoned bunkers
19	Cerro Campana, Panamá	8°41′N-79°56′W	cloud forest
20	Chilibre, Panamá	9°08′N-79°38′W	Chilibrillo Caves
21	Pacora, Panamá	9°04′N-79°18′W	under fig tree
22	Panama (city), Panamá	8°58′N-79°32′W	under fig tree
23	Portobello, Colon	9°41′N-79°41′W	forest trail
24	Chepo, Darien	9°10′N-79°06′W	forest
25	Limon, Costa Rica	9°58′N-83°08′W	coffee finca

[1] Coordinates were compiled from several maps and from Fairchild and Handley (1966).

aranea has not been found associated with any of them. *M. aranea* is found in these areas on *Artibeus,* and its absence from *Desmodus* is significant.

The results of the survey confirm the statement by Wenzel et al. (1966) that "this species appears to be a parasite primarily of *Artibeus jamaicensis*" and secondarily of *A. literatus* in Panamá. Caution should be exercised in extrapolating these results to areas outside Panamá, but collections made in Costa Rica and tropical Mexico indicate that subspecies of *A. jamaicensis* are the primary hosts of *M. aranea* in these countries also. Collections in the care of Dr. Wenzel (pers. comm.) show this to be true also in Venezuela, Surinam, Colombia and San Salvador. *Megistopoda aranea* can be considered monoxenous or, perhaps, oligoxenous.

Field collections can shed light on the behavioral aspects of host selection. No difference was found in the average infestation levels between males and females of *Artibeus jamaicensis,* indicating that the fly may not discriminate between the sexes of its host. This was confirmed in the laboratory with choice tests. The frequency distribution of infestation of *M. aranea* on *A. jamaicensis* follows the expected Poisson (random) distribution (Table 2 and Fig. 4), indicating that the flies do not preferentially segregate with one another and that hosts are nearly alike in their attractiveness. The frequencies of occurrence of both male and female flies on the same host are not significantly different from the expected frequencies, and it may be assumed that flies do not pair with flies of the opposite sex in host selection, in contrast to the situation noted by Hurka (1964) in several European nycteribiids. No correlation of the parasite load with the weight or forearm length of the host was found in a sample of 85 bats.

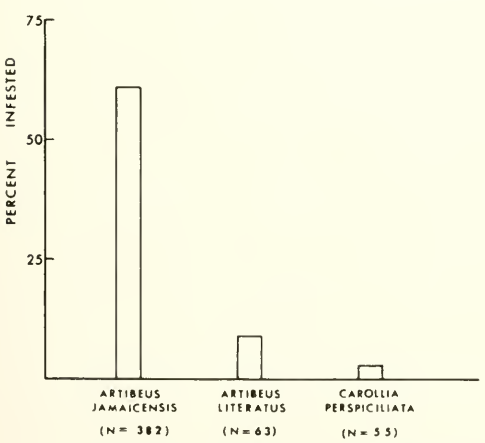


FIG. 3. Frequencies of infestation of *Megistopoda aranea* on three bats species in the Canal Zone.

Although the parasite is buffered from changes in environment by the homeostasis of the host, there were slight differences in the average infestations of *Artibeus jamaicensis* between the wet and dry seasons of 1971. Sixty-two bats caught during the wet season had an average of 0.843 flies per host, compared with 0.611 flies per host found on 57 bats caught during the dry season. That these differences could reflect a direct effect of climate on the parasite is only one possibility. It is also likely that there is an effect on the host, reflected in some significant alteration in its biology. Mares and Wilson (1971) have found a marked seasonality in the breeding cycle of several neotropical bats. Whether such a condition could influence roost selection or sociality of the bats, in such a way that the host-parasite equilibrium would be disturbed, has yet to be explored.

Observations on colonies of *Artibeus jamaicensis* in natural and man-made roosts indicate how the dynamics of host populations may affect the population levels of *Megistopoda aranea.* In several situations bats roosted in close proximity to one another and the fur over which flies moved was effectively continuous from bat to bat. Host-to-host dispersal by this means was suspected and later confirmed. If the

proximity of roosting bats in a colony is assumed as an index of sociality, the possible relationship of sociality to parasitism by *Megistopoda aranea* becomes clearer; dispersal to new hosts becomes dependent upon the sociality of the host. Colony size may also be important for the presence or absence of the parasite, since smaller colonies may not provide sufficient refuge from the grooming activities of individual hosts. While there are no data to support this conjecture, it remains of interest for further investigation.

LIFE CYCLE OF *Megistopoda aranea*

The free-living, non-parasitic stages of *Megistopoda aranea* are reduced, as is the case throughout the Pupipara. The larval stadia last ten days, based on the minimum time between successive pupal depositions by the same female. During this period the larva is nourished in the female by a uterine gland secretion (Hagan, 1951) and is only indirectly dependent upon a host bat. Attempts to demonstrate that gravid females ingested more blood than non-gravid females were inconclusive, and future investigations along these lines may require radioactive tracers to determine the amount of blood ingested. A gravid female ready to expel the prepupa can be distinguished by the degree of enlargement of its abdomen. Such females were removed from hosts and placed in stoppered vials for the collection of puparia.

Within 10 min of its deposition, the

TABLE 2. Frequencies of absence and single and multiple occurrences of *Megistopoda aranea* on *Artibeus jamaicensis*. Expected frequencies are based on a sex ratio of 1 male:1.25 females and a Poisson distribution where the average is 0.843 flies per host for 412 hosts. All hosts were caught in the Canal Zone during June and July of 1971.

No. of flies	Sexes of flies	Observed frequency		Expected frequency	
0	....	....	188	....	177.3
1	1♂	74	133	66.4	149.5
	1♀	86		83.1	
2	2♂	17	68	12.4	63.0
	1♂1♀	27		31.1	
	2♀	24		19.5	
3	3♂	2	18	1.6	17.7
	1♂2♀	5		5.8	
	2♂1♀	10		7.3	
	3♀	1		3.0	
4	4♂	0	3	0.15	3.73
	1♂3♀	1		0.73	
	2♂2♀	1		1.36	
	3♂1♀	0		1.14	
	4♀	1		0.35	
5	....	0	0	....	0.63
6	6♂	0	2	0.001	0.09
	1♂5♀	0		0.006	
	2♂4♀	0		0.017	
	3♂3♀	1		0.026	
	4♂2♀	1		0.024	
	5♂1♀	0		0.013	
	6♀	0		0.003	

Observed and expected frequencies are not significantly different. (Chi-squared test.)

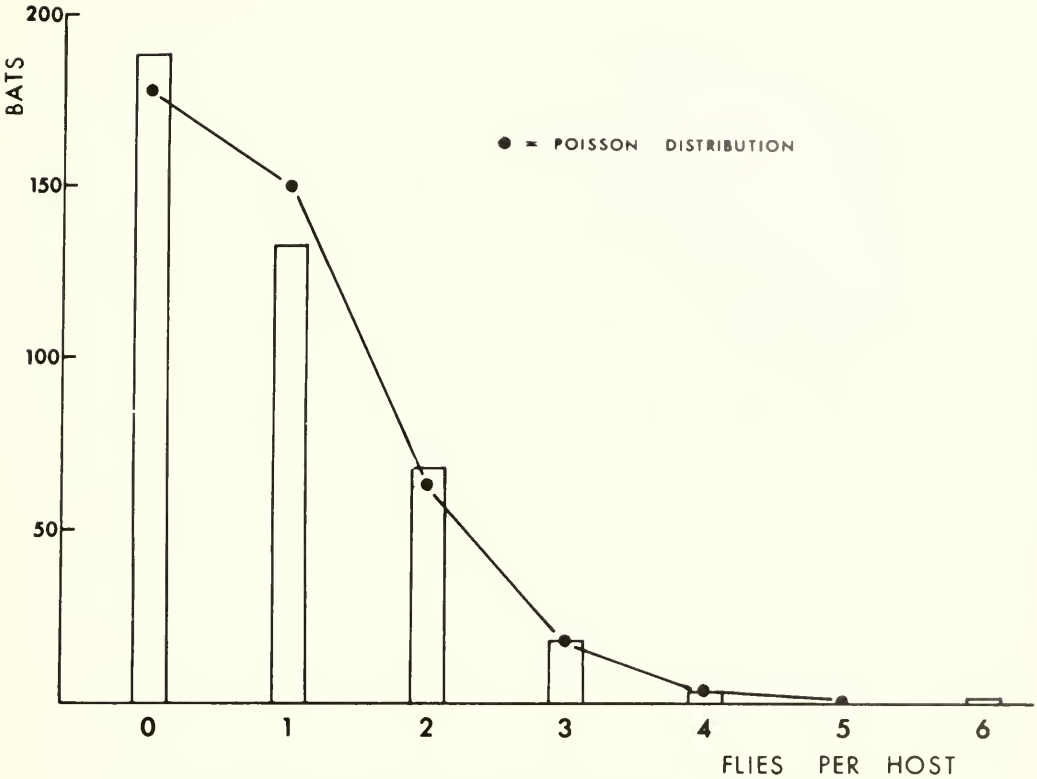


FIG. 4. Frequencies of occurrence of *Megistopoda aranea* on *Artibeus jamaicensis*.

subglobose larva darkens from a transparent colorless form to a brown puparium with evident segmentation. The ventral surface of puparia deposited on glass did not darken, suggesting that the process depends upon contact with air. In addition to the protection afforded it by the toughened larval cuticle, the larva is usually deposited in an indentation. The actual orientation of the puparium does not appear to be important, and both vertical and horizontal surfaces were selected by *M. aranea* for larval deposition. A characteristic place in a stoppered vial was on the glass between the cork and the wall of the vial. In natural colonies of *Artibeus jamaicensis,* puparia were found in areas above the roosting bats. This pupa-position site differs from that of fully winged streblids which may deposit pupae in areas quite removed from the roosting bats, as in a different chamber of a cave, and from that of hippoboscids which may deposit pupae loosely in nesting materials or on the host itself. This last case is not a possibility for *M. aranea,* however, because of the frequent and vigorous grooming by the host and the long developmental period of the pupa.

The pupal stadium lasted 22 to 24 days at 100% R.H. and approximately 22°C. The mean developmental time for 25 pupae was 23 days. The puparium has two posterior spiracles and an oblong base by which it is attached to the substrate (see Hennig, 1952). The dimensions of 25 puparia of *M. aranea* averaged as follows: length—1.6 mm; width—1.1 mm; height —0.8 mm. The teneral adult emerges through an anterior operculum and remains near the empty puparium for several hours. Table 3 shows the survival times of unfed teneral adults. The teneral fly is readily distinguished by its pale color

and crenulate abdomen. A ptilinum was not noted in newly emerged flies.

As observed by Ross (1961) in Arizona, teneral individuals of *Trichobius* spp. cannot mate until they have fed, probably because of the deformation or small size of the abdomen which may be mechanically incapable of copulation. This could apply to *M. aranea* also because no unfed teneral flies were observed to mate. Mating occurs on the host bat and usually lasts one to five minutes. Females were sometimes seen to mate only a few minutes after depositing a pupa.

The presence of both sexes in nearly equal numbers (Table 3) suggests that mating is required for reproduction and that the storage of sperm by the female, if it occurs, is of little importance. Since six adult females separated from males produced maximally only one pupa each during the following three weeks and females which had never been kept with males produced none, a separate mating is probably required for each offspring produced.

Attempts to mark individual flies for life-history studies were unsuccessful due to an apparent toxicity of the oil- and lacquer-based paints which were employed, and measurements of longevity and fecundity are therefore indirect. To measure longevity, newly enclosed *M. aranea* were placed on ten caged *Artibeus jamaicensis* hosts. The flies were counted at weekly intervals (Fig. 5) until the last fly had died or been lost. The average lifespan of these 40 flies was 29 days, and the survivorship curve indicates that the bulk of the mortality was due to sources other than old age. Thirteen dead and damaged flies were recovered from the bottom of the bat cage. Certainly, both the grooming of the host (possibly involving predation) and disassociation from a host should be considered as major causes of mortality. Adults of *M. aranea* were accepted and eaten by *A. jamaicensis* when offered in the laboratory. D. Howell (pers. comm.) has found streblids in the stomachs of several species of Costa Rican bats. An acarine parasite of *M. aranea* adults, *Monunguis streblida* Wharton (Wharton, 1938; Linquist and Vercammen-Grandjean, 1971), has been reported, but no hyperparasites were seen during this study.

Pupal mortality was measured as the percentage of puparia which did not give rise to adults by the end of four weeks. Puparia were deposited on a piece of plywood on top of the outdoor bat cage over the dark corner in which the bats roosted. The board was then removed to the top of an empty cage, and the puparia were examined at the end of a month. Twelve per cent of the puparia (23 of 192) had not given rise to adults, although no reason for their failure could be seen. Two puparia had been damaged (probably in relocating the board) and had been attacked by fungus. The survival of pupae may be assumed to be a function of en-

TABLE 3. Survival times of *Megistopoda aranea* separated from hosts. Both adults which had been allowed to engorge and unfed, newly eclosed tenerals were kept at 100% R.H. and 22°C.

Survival times of engorged adult flies (in hours)	Survival times of unfed teneral flies (in hours)
3	18
5	26
8	36
14	38+
17	
19	
20	

Tenerals survived significantly longer than engorged adults. ($P<.05$) Mann-Whitney-*U* test.)

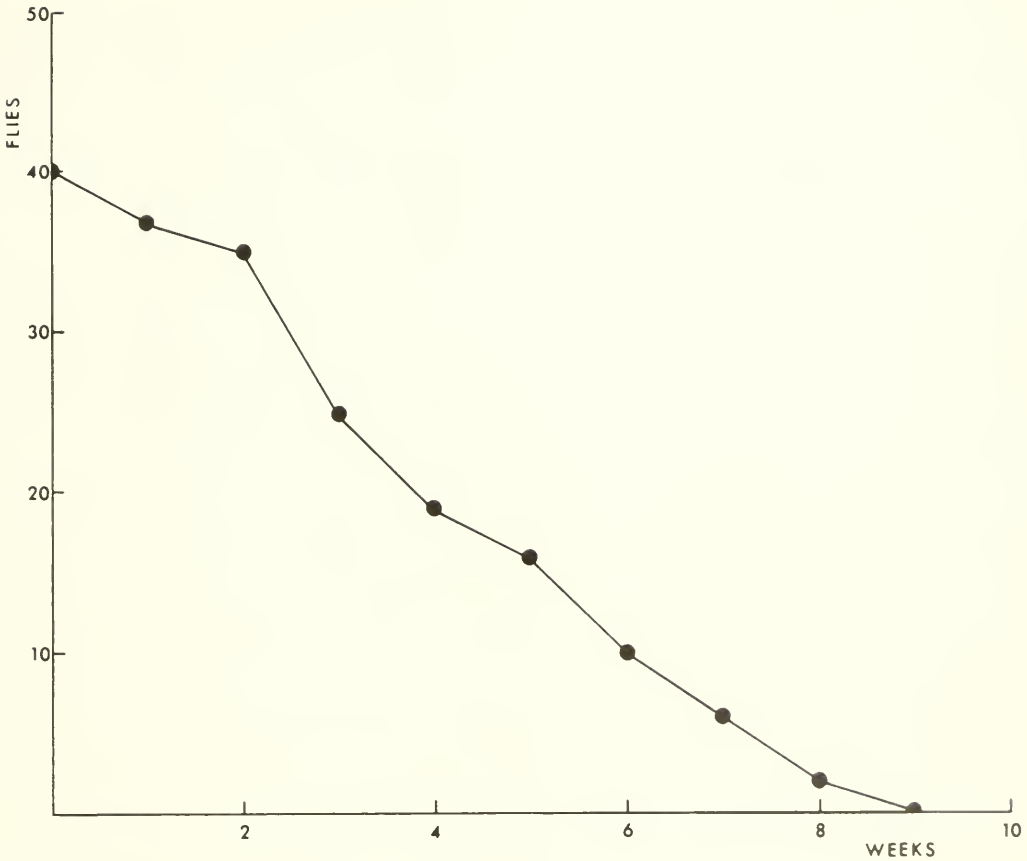


FIG. 5. Survivorship of *Megistopoda aranea* on ten caged *Artibeus jamaicensis*.

vironmental conditions. The present observations, therefore, may reflect more upon the conditions provided for pupal development than on the usual successes of the pupal stage.

In Chilibrillo Caves and in bunkers at Ft. Kobbe, puparia which resembled those of *M. aranea* were found in proximity to colonies of *Artibeus jamaicensis*. Those removed at random in various seasons from the roosts were in a variety of developmental stages, suggesting that reproduction by the bat fly is asynchronous and continuous. The cave and bunker were similar environments with moderate temperatures and a relative humidity near saturation, but colonies of *Artibeus jamaicensis* were also observed in foliage and in a hollow tree where conditions were much different. Pupae in the laboratory developed at 18°C and those in outdoor bat cages at temperatures 21 to 30°C, indicating that unsheltered colonies, if sufficiently permanent, may be parasitized by *M. aranea*.

Life history observations on *M. aranea* indicate a low reproductive potential. Ignoring larval and pupal mortality and assuming adult age-specific fecundities to be equal, the assembled observations would indicate a net reproductive rate, R_o, of 1.45,

where $R_o = \sum_{x} l_x m_x$, l_x is survivorship and m_x is age-specific fecundity. This figure, while derived from data which may include the effects of predation and sub-

optimal conditions, indicates that a population of *M. aranea* would multiply 1.45 times in a generation, while under optimal conditions a greater net reproductive rate would be expected. It seems reasonable to assume that under natural conditions *M. aranea* populations are stable in the long run, although locally there may be extinctions, probably followed by reintroductions and population growth. The low reproductive potential of *M. aranea* follows from its breeding biology which limits a single female to producing maximally one pupa every ten days.

BEHAVIOR OF *Megistopoda aranea*

The dominant aspects of the behavior of *Megistopoda aranea* are its blood-sucking habit and its dependence upon a host. Flies removed from hosts (Table 3) survive for only a short time, in contrast to other groups of ectoparasites which may remain apart from a host for months. *Megistopoda aranea,* therefore, is found in contact with a host during all adult activities with the exception of pupal deposition, which generally occurs close to a resting host during the day. In the terminology of Camin (1963), *M. aranea* can be said to be a "permanent" ectoparasite.

On its host *Megistopoda aranea* can be found on the furred parts of the body, but prefers sites around the neck and shoulders where the fur is long and in the axillary regions below the wings. When disturbed, flies often run into the bat's ears. The fly moves on the host's fur by pushing itself with alternating extensions of the long hind legs. The thoracic sternum is flat and sled-like, and the first two pairs of legs articulate to the sides. The fly can move with facility over the host pelage with its thorax at the level of the longer guard hairs and is capable of moving forward, backward, or to the side. No fly was observed to jump.

During host grooming, *Megistopoda aranea* was seen to retreat to the lower back of its host to a position just anterior to the uropatagium. This portion of its body could not be reached by the host, which groomed itself with its hind claws, thumb and mouth. Host bats were not observed to groom one another as do some birds. Although no pathological lesions were observed at the feeding sites of *M. aranea,* infested *Artibeus* bats were observed to groom more intensively and frequently when the parasite load was experimentally increased. Flies rarely went onto the wings of the host and would not remain on newly born *A. jamaicensis,* which are hairless, suggesting that thigmotaxis is important in host-recognition. This hypothesis was tested by offering flies a choice of substrates in a closed arena; the results are shown in Table 4. Flies consistently chose rougher substrates. Tactile stimuli are probably important in the fly's maintenance of contact with its host.

Megistopoda aranea and other streblids do not engorge, but feed intermittently throughout the day. It is possible that more feeding is done during the daylight hours when the bats are roosting. This is based upon the frequency of defecation by the fly (Fig. 6). Feces were collected on paper at the bottom of a cage containing one *Artibeus jamaicensis* and five *M. aranea.* The higher daytime feeding rates may be induced by a greater rate of desiccation at the lower relative humidity present during the day, or they may be an adaptation to the resting habits of the host during the day. Favored areas for feeding on the host are around the ears and neck and in the axillary regions. Dissections showed that flies apparently ingest whole blood and do not concentrate blood cells. A liquid fecal drop is produced. Although no volumetric measure of the amount of blood ingested by a fly during a day was possible, it remains a possibility that sev-

eral flies could seriously affect the health of their host.

Megistopoda aranea does not appear to bite humans as do some species of *Trichobius* (Ross, 1961). Flies were frequently handled and in two cases given access for several hours to the upper arm of the investigator, but they did not bite. No animals other than bats were accepted as hosts; mice and rats were rejected and flies placed on them left or died. The texture, odor and temperature of the host may be signal stimuli or feeding stimuli to the fly.

Although *Megistopoda aranea* does not normally leave the body fur of its host except for pupal deposition, flies which have been removed from their hosts exhibit search behavior. Placed on a horizontal pane of glass under diffuse light, such a fly would move in a random fashion for several minutes before assuming an "alert" position in which it would stand on its fore- and hind-leg of one side and its mid-leg of the other side. This position was observed in over 50 flies. The legs not used to support the body were extended above the body and waved about. This behavior suggests that tarsal receptors such as those of the Nycteribiidae, or some other type of sensory organ, may be present on the legs of *M. aranea* (Maa, 1971). This stance may also be adaptive for grasping hosts moving nearby. The fly can be made to abandon its "alert" stance and move rapidly if a sudden air current is directed at it, even in the absence of host odor, as from an empty syringe. The fly will turn toward the source of the air current and run forward for several seconds or until the air current is stopped. Such behavior may be adaptive if a potential host were to cause an air current.

In a second type of "search" pattern seen repeatedly in flies removed from hosts to a horizontal surface, the fly moves sideways in a spiral, halting at intervals to raise one or more legs. How effective either of these "search" patterns would be in the more complex environment of a bat roost is not known.

In a "T-tube" apparatus with an internal diameter of about 8 mm, flies were seen to encounter, turn and walk against the flow of air (22 of 25 flies, $P < .05$, Chi-squared test). This may be related to their response to a current of air when standing still.

TABLE 4. Preferences of *Megistopoda aranea* for type of substrate. Fifteen flies (five at a time) were placed in a petri dish with two substrate types, each covering half of the arena, and were allowed to move freely for 20 min before their selection was recorded. Comparisons were made using the Mann-Whitney-*U* test. (*=$P<.05$)

Test no.	Materials as substrates	Trial A	Trial B	Trial C	Preferred material
1	Glass	0	1	0	
	Paper	5	4	5	*
2	Glass	0	0	0	
	Cotton cloth	5	5	5	*
3	Paper	4	3	5	
	Cloth	1	3	5	ns
4	Water	0	0	0	
	Glass	5	5	5	*
5	Moist towel	0	3	1	
	Glass	5	2	4	ns
6	Cotton	0	1	0	
	Bat fur	5	4	5	*
7	Wet bat fur	0	1	0	
	Dry bat fur	5	4	5	*

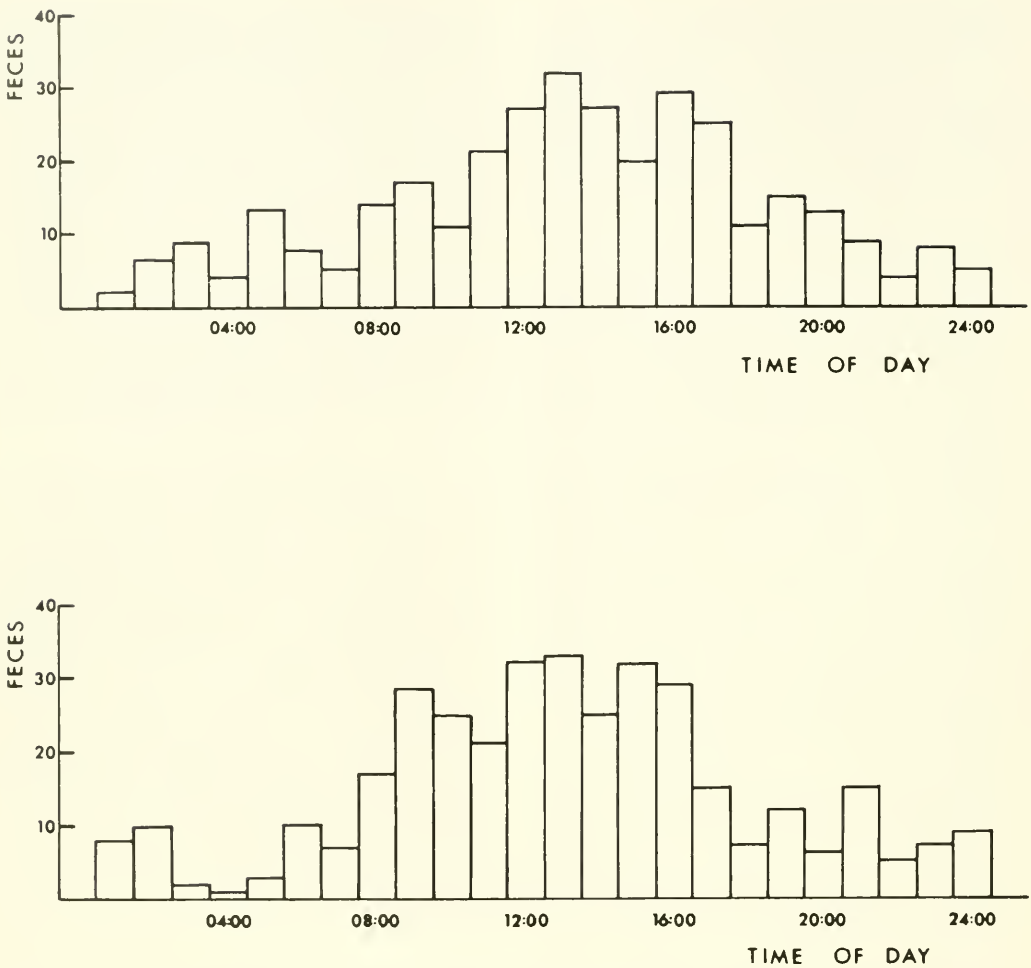


FIG. 6. Defecation rate of five feeding *Megistopoda aranea* during a 48-hour period.

Table 5 shows the results of chemosensory tests using a "T-tube" in which the various stimuli were allowed to diffuse from one end of the "T" for one-half hour before the flies were introduced into the stem. None of the stimuli was shown to have a marked attraction or other effect except the commercial insect repellent. This indicates that, while some olfaction is present, it may not be used in host-finding. This could be expected since the environment of the bat fly is probably saturated with the host odor, and no gradient of odor could be followed to find the host bat over the short distances the flies walk from their hosts.

Host temperature is a valid clue for many ectoparasites in host-recognition and host-finding over small distances. It may also be a feeding stimulus. It appears that *M. aranea* is sensitive to substrate temperature (Table 6). Flies consistently aggregated in the area of a temperature gradient which was between 33 and 38°C. This temperature range includes the body fur temperature of resting *Artibeus jamaicensis* which was measured with a "banjo" probe and a Yellow Spring Instrument

Company tele-thermometer. These bats had a surface temperature of 32° ± 2°C, but temperatures rose rapidly as the bat struggled to free itself or bit the thermistor probe. Bats generally have fluctuating body temperature, and many resting bats allow their temperature to rise or drop to the ambient temperature (Henshaw, 1970). *Artibeus* bats were not tested in an unstressed condition, and it is not known if this is true for them. Only to the extent that their temperature remains above ambient can temperature preference be dependable for host-finding by their parasites.

Host-finding is initially important to *Megistopoda aranea* of both sexes after eclosion. The teneral adult can survive longer without a host than can a fed adult (Table 3). This result agrees with the findings of Marshall (1970*a*) and Leong and Marshall (1968) for two nycteribiid species. The initial advantage is probably greater for *M. aranea,* however, because no host-associated stimulus for eclosion seems to be involved which would indicate the presence of a host, such as has been reported for *Basilia hispida* (Nycteribiidae) (Marshall, 1970*a*, 1970*b*). Even if such a stimulus were present, the roosting sites of *Artibeus* are shared with other species, and the bat which may trigger eclosion could be one of a number of stenodermine or other bats. No doubt newly emerged flies could get onto irregular hosts which have replaced an *Artibeus* colony.

Flies did not select a particular relative humidity in a gradient, nor were they excited or stimulated to move by low concentrations of carbon-dioxide in the air. They did not preferentially select either light or dark areas in an arena, and their distribution in a vertical cylinder was without regard to gravity. *Megistopoda aranea,* like other streblids, can walk upside-down on glass and could even adopt the "alert" stance in this orientation.

Table 7 indicates that *Megistopoda aranea* has the ability to discriminate between host species that are roosting together or in close proximity. The sensory basis for this discrimination is unknown, although olfaction is suspected. Another

TABLE 5. Results of chemosensory behavioral tests. For an explanation of the experimental design see text.

Stimulus	Locomotory response	Number responding (20 flies)
Host hair	weak positive	1
Host breath	none	0
Host faeces	none	0
Water washings of host	none	0
"OFF" (50%, N,N,-dimethyl-meta-toluamide)	strong negative	19

TABLE 6. Temperature preference of *Megistopoda aranea.* Positions of flies on a warmed glass plate were recorded with reference to substrate temperature after 20 minutes of free movement. A shielded 100-watt light bulb was the heat source. Air temperature was 18°C. Expected numbers of flies are based on relative areas of the substrate in each temperature range.

Temperature (°C)	No. of flies	Expected number
18-20	2	12
21-23	4	9
24-26	4	9
27-29	3	8
30-32	9	6
33-35	18	4
36-38	7	2

Observed distribution of flies by area does not fit the expected (random) distribution. ($P<.05$, Chi-square test.)

factor observed which may bear on these results is that *Carollia perspicillata, Glossophaga soricina,* and *Artibeus toltecus* are small bats and groom themselves more vigorously and frequently than do the larger *Artibeus jamaicensis* and *A. literatus*. Batflies, therefore, may have been groomed off by the more active hosts. The fur of the smaller bats is also shorter and may be more difficult for the batflies to grasp. Thus, the association of parasite and host could result from factors other than sensory orientation.

Similarly, the survival of *Megistopoda aranea* on various hosts may depend upon factors other than the nutritive requirements of the fly or the presence of phagostimulants. Of the bat species listed in Table 8, *Carollia* spp., *Glossophaga* sp., *Uroderma bilobatum* and *Stirnira* sp. did not adapt well to captivity. Individuals of these species showed signs of agitation and stress, did not adapt well to the diet provided, and had to be released after about a week if they were not to be kept as voucher specimens. Three *Artibeus cinereus* were kept with sheaths over hind claws, wings and mouth, and were forcefed for one week during which time two *M. aranea* were maintained on each without loss. It seems reasonable, therefore, that the survivorship of the bat fly on several hosts was dependent upon differences in host activities, including grooming.

Ecological Considerations

To the batfly the bat is both habitat and food, while the batfly causes a loss of

TABLE 7. Host species selection by *Megistopoda aranea*. Four flies were placed in each cage containing a male and female of two bat species. Host-selection of flies was recorded after one, two, and three days. Host-selection by sex was non-significant in each species. (*$P<.05$; Mann-Whitney-*U* test.)

Cage	Hosts	Day 2	Day 3	Day 4
I	*Artibeus jamaicensis*	1	3	1
	Artibeus literatus	3	1	3
II	*Artibeus jamaicensis**	4	4	3
	Carollia perspicillata	0	0	1
III	*Artibeus jamaicensis**	4	3	3
	Glossophaga soricina	0	1	1
IV	*Artibeus jamaicensis*	2	1	2
	Phyllostomus discolor	2	3	2
V	*Artibeus jamaicensis**	4	3	4
	Artibeus toltecus	0	1	0
VI	*Artibeus literatus**	3	4	4
	Carollia perspicillata	1	0	0

TABLE 8. Survival times of *Megistopoda aranea* on various hosts. Two flies were placed on each of three bats of each listed species. Each bat was kept separately in a fine wire-mesh cage and checked daily.

Host species	Number of flies surviving				
	Day 1	Day 2	Day 3	Day 4	Day 5
Artibeus j. jamaicensis	6	6	6	6	6
Artibeus literatus	6	6	6	6	6
Artibeus cinereus	6	5	2	2	1
Carollia perspicillata	6	4	1	0	0
Glossophaga soricina	6	5	5	5	5
Glossophaga sp.	6	4	0	0	0
Phyllostomus hastatus	6	6	6	4	4
Phyllostomus discolor	6	5	3	1	1
Uroderma bilobatum	6	4	3	3	3
Stirnira sp.	6	3	1	1	0

fitness to its host bat. The accommodations between hosts and parasites are paralleled on the level of their populations, for the relationship may be viewed as involving a population of parasites and a population of hosts, the properties of neither being fully derivable from the properties of individual hosts or parasites.

Although a single batfly can affect only one bat at a given time, it may parasitize several or even many host individuals during its lifetime. Table 9 shows the results of an inquiry into the ability of *M. aranea* adults to disperse from one bat to other bats in its colony. So rapid was this dispersal and redistribution that the bat colony must be considered the effective host unit for a batfly for any but the shortest time scale. It is, however, premature to conjecture about the effect of the presence of additional bats in the colony upon the immediate environmental conditions affecting the parasite since the effective microclimate of the batfly is not known, but speculation on the effect of host population densities or colony sizes on parasite incidence may now be fruitful. If, for example, the size of a colony governs its stability or the permanence of its roost in some manner, it would greatly influence the reproductive success of its associated batflies, which require bats to be present for emergent adults following pupation. Likewise, a larger colony may afford a batfly more opportunity to abandon a dying or unsuitable bat for a more suitable host.

The potential of *Megistopoda aranea* to transmit diseases would seem great. Sergent and Sergent reported the transmission of *Haemoproteus columbae* by the pigeonfly *Pseudolynchia maura,* a hippoboscid, in 1906 (Coatney, 1931); and O'Roke (1930) demonstrated that *Haemoproteus lophortyx,* a blood parasite of quail, is transmitted by another hippoboscid, *Lyn-*

TABLE 9. Host-to-host transfers of *Megistopoda aranea.* Ten flies were introduced onto one of five *Artibeus jamaicensis* (A) in each of five cages to determine how the flies would distribute themselves among the caged hosts. Flies were not marked in order to avoid possible injury. The incidence of the flies on each of the hosts was checked daily for five days.

Cage	Host	Day 1	Day 2	Day 3	Day 4	Day 5
I	A	10	8	5	2	2
	B	0	0	2	3	1
	C	0	0	0	1	1
	D	0	1	1	0	3
	E	0	0	0	2	1
II	A	10	6	3	2	3
	B	0	3	2	2	2
	C	0	0	1	2	1
	D	0	1	2	2	1
	E	0	0	0	0	0
III	A	10	3	3	0	1
	B	0	1	2	1	2
	C	0	1	0	1	2
	D	0	3	4	3	2
	E	0	2	0	4	1
IV	A	10	2	2	3	3
	B	0	1	2	1	2
	C	0	4	0	1	2
	D	0	2	0	2	1
	E	0	2	5	0	2
V	A	10	5	2	0	3
	B	0	0	1	5	3
	C	0	2	1	2	2
	D	0	0	4	1	0
	E	0	3	2	0	0

chia hirsuta. Transmission of this sort is more complex than the mechanical transmission required for the bacterial or viral diseases to which *Artibeus jamaicensis* is known to be susceptible. Moving from one host individual to another, *M. aranea* would appear to pose a threat to the health of *Artibeus* colonies if it serves as a vector for diseases of its hosts. Rabies may be spread as an aerosol, and investigations of the transmission of rabies in bats at the Trinidad Virus Laboratory did not implicate batflies as vectors (Greenhall, pers. comm.). One limitation to the vectorship-potential of *M. aranea* is its narrow host range, but further inquiry into this matter is warranted.

Artibeus jamaicensis is the host of other blood-sucking ectoparasites which would appear to compete with *Megistopoda aranea*. Other parasites collected on *A. jamaicensis* during the course of this investigation included three streblids, *Paratrichobius longicrus, Aspidoptera buscki,* and *Metelasmus pseudopterus,* and a spinturnicid mite, *Periglischrus iheringi*. Other parasites of *Artibeus jamaicensis* are reported by Wenzel et al. (1966). While these three other streblids, especially, could compete with *M. aranea,* other parasites did not exclude *M. aranea*. It would seem that *Artibeus* in Panamá has not been "saturated" with parasites and that populations of parasites of *Artibeus jamaicensis* are not at their maxima. Competition between ectoparasites would not be expected if their resources were not limiting.

If, however, a host bat is considered as a limited habitat, it is possible that populations of *Megistopoda aranea* are at their maxima and that competition between ectoparasitic species for space, rather than food, may occur. The potential maximum population would be a function of the host's behavioral tolerance for parasites, and parasites in excess of this limit would be removed by host grooming. The advantage under such pressures would lie with those parasites which could best avoid being dislodged. *M. aranea* is by far the most common ectoparasite of *A. jamaicensis* and presumably has this ability to a greater extent than do other parasites.

Summary

Megistopoda aranea is the most frequent ectoparasite of *Artibeus jamaicensis* in Panamá where this study was conducted. *Artibeus literatus* is a much less frequent host. In spite of this, *M. aranea* is best considered as monoxenous, forming a stable system with its host. *Megistopoda aranea* disperses from host to host within a colony by direct transfer between adjacent hosts. The frequency distribution of flies on *Artibeus jamaicensis* resembles the expected Poisson distribution. The sexes of *Megistopoda aranea* are present in nearly equal numbers. Copulation is required for each reproduction. The larval stages last about 10 days in the body of the mother, and the pupal stage lasts about 23 days. The adult *Megistopoda aranea* lives several weeks. Breeding occurs throughout the year. The reproductive potential of the species seems to be limited by its viviparous habit. A description of the general and orientation behavior of *Megistopoda aranea* is given. Host-specificity of *Megistopoda aranea* may arise from ecological aspects of the host, rather than from the fly's sensory orientation.

Resumen

Megistopoda aranea es el ectoparásito más frecuente en *Artibeus jamaicensis* de Panamá. *Artibeus literatus* es un huésped de segundo orden, por su escasez. Por lo que *Artibeus jamaicensis* puede ser considerado como un huésped específico para *Megistopoda aranea*. El metodo de dispersión usado por *Megistopoda aranea* dentro de una colonia es por contacto directo entre los huéspedes. La distribucion de

frecuencia de *Artibeus jamaicensis* semeja la distribucion de Poisson. Hombras y machos de *Megistopoda aranea* se encuentran en igual número. Cada vez que se reproducen es necesaria la copulación. El estado larval dura 10 días dentro del cuerpo de la madre el estado pupal dura 23 días. Los adultos de *Megistopoda aranea* viven varias semanaś la reproducción se realiza durante todo el año. El potencial reproductivo de la especie parece estar limitado por sus modo vivíparo de reproducción. Descripción acerca de la conducta de *Megistopoda aranea* es incluida. La especificidad de *Megistopoda aranea* esta possiblemente más replacionada con la ecología del huésped que con la orientación sensorial del parásito hacia el huésped.

ACKNOWLEDGMENTS

I wish to acknowledge the advice and assistance given me in Kansas and Panamá by Dr. George W. Byers and Dr. Robert E. Beer of the University of Kansas. Dr. Rupert L. Wenzel, Curator of Zoology of the Field Museum of Natural History, made helpful suggestions and provided specimens for comparison in the identification of the batfly. Bats were identified by Dr. E. Tyson, and by Dr. John Farney. Mr. Charles M. Keenan has been most generous with his time and advice in the field. I also wish to thank Dr. William Ramírez for advice and assistance in the field.

I thank the Smithsonian Tropical Research Institute (Ancon, Canal Zone) for partial support and the use of the research facilities at Barro Colorado Island. Logistic support was also received from the Snow Entomological Museum of the University of Kansas and from the Field Museum of Natural History. Funds for computer analyses were provided through the University of Kansas Computation Center.

LITERATURE CITED

ALDRICH, J. M. 1907. Additions to my catalogue of North American Diptera. J. New York Entomol. Soc. 15:2-9.

BEQUAERT, J. C. 1953. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part I. Structure, physiology and natural history. Entomologica Americana 32:1-209; 33:211-442.

CAMIN, J. H. 1963. Relations between host-finding behavior in life histories in ectoparasitic acarina. Advances in Acarology 1:411-424.

COATNEY, G. R. 1931. On the biology of the pigeon fly. Parasitology 23:535-542.

CONSTANTINE, D. G. 1970. Bats in relation to the health, welfare and economy of man, p. 319-449. *In* W. A. Wimsatt (ed.), The Biology of Bats, Vol. 2. Academic Press, N.Y. and London.

COQUILLETT, D. W. 1899. New genera and species of Nycteribiidae and Hippoboscidae. Can. Entomol. 31:333-336.

FAIRCHILD, G. B., and C. O. HANDLEY. 1966. Gazetteer of collecting localities in Panama, p. 9-22. *In* R. L. Wenzel and V. J. Tipton (eds.), Ectoparasites of Panama. Field Museum of Natural History, Chicago.

GOODWIN, G. G., and A. M. GREENHALL. 1961. A review of the bats of Trinidad and Tobago. Bull. Amer. Mus. Nat. Hist. 122:187-302.

GREENHALL, A. M., and J. L. PARADISO. 1968. Bats and bat banding. Bureau of Sport Fisheries and Wildlife, Publ. No. 72, p. 1-48. Washington, D.C.

HAGAN, H. R. 1951. Embryology of the Viviparous Insects. McGraw-Hill, Inc., N.Y.

HASE, A. 1931. Ueber die Lebensgewohnheiten einer Fledermausfliege in Venezuela, *Basilia bellardi* Rondani. Beiträge zur experimentellen Parasitologie 5. Z. Parasitenk. 3:220-257.

HENNIG, W. 1952. Die Larvenformen der Dipteren. Vol. 3. Akademie-Verlag, Berlin.

HENSHAW, R. E. 1970. Thermoregulation in bats, p. 188-232. *In* R. H. Slaughter and D. W. Walton (eds.), About Bats: A Chiropteran Biology Symposium. Southern Methodist Univ. Press, Dallas.

HILL, D. S. 1963. The life history of the British species of *Ornithomyia*. Trans. Royal Entomol. Soc. London 115:391-407.

HOFFMANN, A. 1953. Estado actual del conocimiento de los estreblidos mexicanos. Mem. Congr. Cient. Mex. 7:175-193.

HURKA, K. 1964. Distribution, bionomy and ecology of the European bat flies with special regard to the Czechoslovak fauna. Acta Universitatis Carolinea, Biologica 1964:167-234.

JOBLING, B. 1949. Host-parasite relationship between the American Streblidae and the bats, with a new key to the American genera and a record of the Streblidae from Trinidad, British West Indies. Parasitology 39:315-329.

———. 1952. Description of two new species of *Ascodipteron* from Africa and one species of

Nycteribosca from Madagascar. Parasitology 42: 126-135.

LEONG, M. C., and A. G. MARSHALL. 1968. The breeding biology of the batfly *Eucampsipoda sundaicum*. Malay Nature J. 21:171-180.

LINQUIST, E. E., and P. H. VERCAMMEN-GRANDJEAN. 1971. Revision of the chigger-like larvae of the genera *Neotrombidium* Leonardi and *Monunguis* Wharton, with a redefinition of the subfamily Neotrombidiinae Feider in the Trombidiidae (Acarina: Prostigmata). Can. Entomol. 103: 1557-1590.

MAA, T. C. 1965. An interim world list of batflies. J. Med. Entomol. 1:377-386.

———. 1971. An annotated bibliography of batflies (Diptera: Streblidae; Nycteribiidae). Pacific Insects Monograph 28:119-211.

Machado-Allison, C. E. 1966. Notas sobre Streblidae de Venezuela. Acta Biol. Venezuela 5:69-79.

MACQUART, P. J. M. 1852. Notice sur nouveau genre de Diptères de la Famille des Pupipares, Tribu des Phthiromydes, sous le nom de *Megistopoda*. Ann. Soc. Entomol. France 10:331-333.

MARES, M. A., and D. E. WILSON. 1971. Bat reproduction during the Costa Rican dry season. BioScience 21:471-477.

MARSHALL, A. G. 1970 *a*. The life cycle of *Basilia hispida* Theodor, 1967, in Malaysia. Parasitology 61:1-18.

———. 1970 *b*. The ecology of *Basilia hispida* (Diptera: Nycteribiidae) in Malaysia. J. Anim. Ecol. 40:141-154.

MATHESON, R. 1928. Notes on a small collection of bat ecto-parasites. Parasitology 20:173-174.

MUIR, F. 1911. Bat and parasitical dipteron. Proc. Entomol. Soc. London 1911:16-17.

NOVICK, A. 1960. Successful breeding in captive *Artibeus*. J. Mammal. 41:508-509.

O'ROKE, E. C. 1930. The morphology, transmission and life-history of *Haemoproteus lophortix* O'Roke, a blood parasite of the California valley quail. Univ. California Publ. Zool. 36:1-50.

RODHAIN, J., and J. BEQUAERT. 1916. Observations sur la biologie de *Cyclopodia greeffi* Karsch, Nycteribiide parasite d'une chauve-souris congolaise. Bull. Soc. Zool. France 40:248-262.

Ross, A. 1961. Biological studies on bat ectoparasites of the genus *Trichodius* in North America, north of Mexico. Wasmann J. Biol. 19:229-246.

RYBERG, O. 1947. Studies on Bats and Bat Parasites. Bokforlaget Svensk Natur., Stockholm.

SCHULZ, H. 1939. Ueber Fortpflanzung und Verkommen von Fledermausfliegen. Z. Parasitenk. 10:297-328.

SOKAL, R. R., and F. J. ROHLF. 1969. Biometry. W. H. Freeman and Co., San Francisco.

SPEISER, P. G. E. 1900. Ueber die Strebliden, Fledermausparasiten aus der Gruppe der pupiparen Dipteren. Arch. Naturg. 66:31-70.

STILES, C. W., and M. O. NOLAN. 1931. Key catalogue of parasites reported for Chiroptera (bats) with their possible public health importance. National Inst. Health Bull. 155:603-742, 767-789.

THEODOR, O. 1957. Parasitic adaptation and host-parasite specificity in the pupiparous Diptera, p. 50-63. *In* E. Mayr (ed.), First Symposium on Host Specificity among Parasites of Vertebrates. Inst. Zool., Univ. Neuchatel.

TONN, R. J., and K. ARNOLD. 1963. Ectoparásitos de aves y mammíferos de Costa Rica. 1. Diptera. Rev. Biol. Trop. 11:171-176.

WENZEL, R. L. 1970. Family Streblidae, p. 100.1-100.25. *In* A Catalogue of the Diptera of the Americas South of the United States, Part 100. Museu de Zoologia, Universidade de São Paulo.

WENZEL, R. L., and V. J. TIPTON. 1966. Some relationships between mammal hosts and their ectoparasites, p. 677-723. *In* R. L. Wenzel and V. J. Tipton (eds.), Ectoparasites of Panama. Field Museum of Natural History, Chicago.

WENZEL, R. L., V. J. TIPTON, and A. KIEWLICZ. 1966. The streblid batflies of Panama, p. 405-675. *In* R. L. Wenzel and V. J. Tipton (eds.), Ectoparasites of Panama. Field Museum of Natural History, Chicago.

WHARTON, G. W. 1938. Acarina of Yucatan caves. Carnegie Inst. Washington Publ. 491:137-152.

UNI
8124

MUS. COMP. ZOOL.
LIBRARY
DEC 24 1980
HARVARD
UNIVERSITY

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

A COMPARATIVE ECOLOGICAL STUDY OF THE WOOD COCKROACHES IN NORTHEASTERN KANSAS

By

Robert E. Gorton, Jr.

Vol. 52, No. 2, pp. 21-30 December 1, 1980

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 2, pp. 21-30 December 1, 1980

A Comparative Ecological Study of the Wood Cockroaches in Northeastern Kansas

Robert E. Gorton, Jr.
Department of Entomology, University of Kansas, Lawrence, Kansas 66045

CONTENTS

Abstract 21
Introduction 21
Materials and Methods 22
Observations and Results 23
Habitat preferences 23
Vertical stratification 23
Species diversity and evenness of distribution 24
Feeding behavior 25
Predators 25
Interactions 25
Seasonal population cycles 25
Discussion 25
General patterns of species distribution 25
General patterns of species diversity 27
Competition, abundance, and community structure 29
Literature Cited 30
Acknowledgments 30

Abstract

A field study of the ecology and natural history of the native cockroaches in Northeastern Kansas was undertaken in the vicinity of Lawrence, Kansas. Such parameters as vertical and horizontal distributions, relative abundances, food preferences, and population peaks were identified for each of the six species in the genera *Parcoblatta* and *Ischnoptera*, comprising the cockroach community in this area. The results are explained as mechanisms for co-existence and other adaptations to the biotic and abiotic environments encountered by the insects.

Introduction

Although the wood cockroaches in the genera *Parcoblatta* and *Ischnoptera* are common insects in much of the United States, the information available concerning the species in these genera is sparse and anecdotal (Gould and Deay, 1938, 1940; Rau, 1940). Blatchley (1920) gave general habitat descriptions for the various species, but most of his information was gathered in a nonrigorous manner. Lawson (1967) provided habitat descriptions of wood cockroaches in Kansas from trap data, but without quantification. No systematic effort has been made to carefully examine the distribution, relative abundances, population dynamics, and general natural history of the several commonly sympatric species of wood cockroaches comprising a typical temperate cockroach community (but see Friauf, 1953; Dreisig, 1971).

This study focused on six species of cockroach found in Douglas and Jefferson counties, Kansas: *Parcoblatta pennsylvanica, P. lata, P. uhleriana, P. virginica, P. bolliana,* and *Ischnoptera deropeltiformis*. The major objectives were to

elucidate the above-mentioned parameters, observe the behavior of the animals during their nocturnal activity periods, determine the community structure, and observe as many intraspecific and interspecific interactions as possible in a natural context.

MATERIALS AND METHODS

The study areas were within the University of Kansas Natural History Reservation and the Nelson Environmental Study Area, approximately 15 km north of Lawrence, Kansas. These areas represent several discrete habitat types (Fig. 1): forest—representative flora being basswood *(Tilia americana),* black walnut *(Juglans nigra),* and red and bur oak *(Quercus rubra* and *Q. macrocarpa,* respectively), with an understory of poison ivy *(Toxicodendron radicans),* rough-leaved dogwood *(Cornus drummondii),* Buckbrush *(Symphoricarpos orbiculatus),* and big bluestem *(Andropogon gerardi);* an ecotone of thickets and shrubland—typical flora being red elm *(Ulmus rubra),* smooth sumac *(Rhus glabra),* white ash *(Fraxinus americana),* and bluestem *(Andropogon* spp.); and grassland—dominated by such plants as smooth brome *(Bromus inermus),* common milkweed *(Asclepias syriaca),* switch grass *(Panicum virgatum),* and tall goldenrod *(Solidago altissima)* (Martinko, 1976; Birdsell and Hamrick, 1978; J. L. Hamrick, pers. comm.).

Observations were made at night from May to September, 1977 and 1978. Censusing was done along approximately the same route each time for 3-5 h (Fig. 1). The time was about equally divided between forest and nonforest areas. If less than 66.67% of the individuals of a given species were found in a general habitat (forest or nonforest), that species was considered to have no particular habitat preference. Most observations (>98%) were made at the Nelson Area.

Each cockroach observed in the field

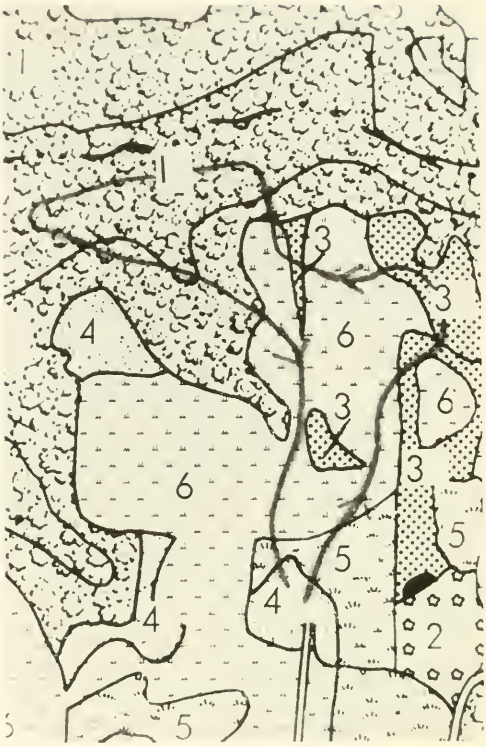


FIGURE 1. Map of the primary study area at the Nelson Environmental Study Area. Legend: 1-2, forest; 3-4, thickets and shrublands (mostly woody plants less than 5 m tall); 4-6, grassland. Arrowed line denotes approximate path taken for observations. Scale: 1 cm = 50 m.

was identified as to sex and species, without disturbing the animal if possible. Substrate, vertical height, habitat, and activity were recorded for each sighting. Animals attracted to lights or collected nearby but well outside the study areas were counted in the seasonal abundance calculations only.

Differences in intraspecific intersexual vertical distributions and shifts in these distributions as a function of habitat change were determined with the Mann-Whitney *U*-test (Conover, 1971). Interspecific comparisons of the vertical distributions of each sex were made with an ANOVA and an *SNK* test (Sokal and Rohlf, 1969). The Shannon-Weiner Index was used to measure species diversity between forest and nonforest areas for both

sexes and between the various major substrates (e.g., ground, grass, etc.) (Pielou, 1969). This index is given as: $H' = -\Sigma P_i \ln P_i$ where S is the number of species in the assemblage and P_i is the relative abundance of the ith species. Evenness was calculated by $J' = H'/\ln S$, where H' is the Shannon-Wiener Index of species diversity and S is the number of species present (Pielou, 1969).

Observations and Results

Habitat Preferences

From the criterion for assigning general habitat preferences to a species *Parcoblatta lata* and *Ischnoptera deropeltiformis* were considered species of prairie and disturbed grassland, while *P. bolliana, P. virginica,* and *P. uhleriana* were considered forest species. *Parcoblatta pennsylvanica* was found in both general habitats, primarily on trees (Table 1). None of these species (especially females), however, was restricted to a particular habitat. In the disturbed areas, females were primarily found moving about on the ground, while males were usually seen on or flying to blades of grass (Fig. 2). In the forest, females of *P. uhleriana* and *P. virginica* were usually observed on the ground and the rare *P. bolliana* females were found either on the ground or on forbes and bushes. Males of *P. virginica* were observed primarily on bushes and trees; males of *P. bolliana* almost entirely on bushes. *Parcoblatta uhleriana* males were primarily found on bushes, but also commonly frequented the grass and ground. Males of this species were the most general in substrate choice. *Parcoblatta pennsylvanica* males were usually seen on the trunks of the larger trees, while the females of this species were found on the ground as well as on trees.

Vertical Stratification

In five of the six species studied, males occurred at significantly higher points in the environment than females (Table 2). The exception, *P. bolliana,* showed no differences in mean height preferences be-

Table 1. Numbers and percentages of individuals of each species found in forest and nonforest habitats.

	P. lata			*P. virginica*		
	Nonforest	Forest	Total	Nonforest	Forest	Total
Males	47 (75.8%)	15 (24.2%)	62	9 (26.5%)	25 (73.5%)	34
Females	31 (64.6%)	17 (35.4%)	48	4 (10.0%)	36 (90.0%)	40
Total	78 (70.9%)	32 (29.1%)	110	13 (17.6%)	61 (82.4%)	74
	I. deropeltiformis			*P. pennsylvanica*		
	Nonforest	Forest	Total	Nonforest	Forest	Total
Males	46 (82.1%)	10 (17.9%)	56	41 (55.4%)	33 (44.6%)	74
Females	8 (61.5%)	5 (38.5%)	13	69 (58.5%)	49 (41.5%)	118
Total	54 (78.3%)	15 (21.7%)	69	110 (57.3%)	82 (42.7%)	192
	P. bolliana			*P. uhleriana*		
	Nonforest	Forest	Total	Nonforest	Forest	Total
Males	1 (12.5%)	7 (87.5%)	8	22 (37.3%)	37 (62.7%)	59
Females	1 (16.7%)	5 (83.3%)	6	38 (28.8%)	94 (71.2%)	132
Total	2 (14.3%)	12 (85.7%)	14	60 (31.4%)	131 (68.6%)	191

tween the sexes. *Parcoblatta pennsylvanica* males were significantly higher up on the vegetation than all other males (ANOVA, $F=316.53$, $P<.001$; *SNK* test, $P<.05$), and *P. pennsylvania females* were significantly higher than all other females but those of *P. bolliana* (ANOVA, $F=39.11$, $P<.001$; *SNK* test, $P<.05$). No other differences in intrasexual mean height preferences were found for either sex.

The average height chosen by one or another of the sexes changed with general habitat (forest or nonforest) in four of the six species studied (Table 3). In each case, forest "populations" were higher off the ground than nonforest "populations."

I saw ten copulating pairs during the study. The range of heights at which *P. pennsylvanica* copulated was large: 53.34-365.76 cm ($\bar{X}=188.59\pm71.97$; $N=4$). The pooled heights of copulating pairs of the remaining five species ranged over only 13.3 cm: 20.32-33.02 cm ($\bar{X}=27.86\pm1.87$; $N=6$).

Species Diversity and Evenness of Distribution

When the species composition of forest and nonforest areas were compared, the species diversity and evenness indices were identical (Table 4). The male community, however, showed greater diversity in the nonforest areas and the female community showed greater diversity in the forest areas. Comparisons by vegetation type revealed low species diversity on trees and buildings and high diversity on forbs and bushes. Males reflected this same general trend. The female communities, on the other hand, were most diverse on the ground and least diverse on trees and buildings. The low diversity on trees and buildings was due to the preference of *P. pennsylvanica* for these substrates (Fig. 2).

TABLE 2. Mean heights (cm) at which males and females were found, with one standard error around the means. Heights were compared with the Mann-Whitney *U*-test.

Species	Males	Range	Females	Range	U_s	α-level
P. bolliana	59.36±17.51	0-121.92	67.72±52.96	0-304.80	33	>.10
P. uhleriana	62.06±11.71	0-609.60	7.02±2.35	0-187.96	7330	.0001
P. virginica	70.95±10.96	0-274.32	13.84±5.38	0-137.16	1240.5	.0001
P. lata	63.68±4.62	0-152.40	18.78±8.76	0-365.76	2790	.0001
P. pennsylvanica	120.42±13.02	0-548.64	92.56±10.59	0-609.60	6460	.0001
I. deropeltiformis	51.02±4.29	0-150.00	1.92±2.09	0-25.00	717.5	.0001

TABLE 3. Differences in mean height preferences between forest and nonforest areas (cm±1 SE), compared with the Mann-Whitney *U*-test. Only those species showing significant differences are given.

Species	Sex	Height: forest	Height: nonforest	U_s	α-level
P. virginica	Female	14.00±5.79	0.00±0.00	108	0.05
P. lata	Female	45.72±23.89	5.31±4.05	375	0.01
P. uhleriana	Female	7.12±2.96	4.51±3.09	3307.5	0.0001
P. uhleriana	Male	70.96±17.91	42.29±9.25	488	0.05
I. deropeltiformis	Male	59.13±16.95	49.37±7.37	311.5	0.05

TABLE 4. Species diversity and evenness indices of the cockroach community calculated by general habitat (forest and nonforest) and substrate (grass, ground, etc.), with 1 SD.

Habitat	*H'* (both sexes)	*J* (both sexes)	*H'* (male)	*J* (male)	*H'* (female)	*J* (female)
Forest	1.49±.04	.83	1.51±.01	.85	1.61±.05	.90
Nonforest	1.49±.03	.83	1.64±.04	.92	1.39±.05	.78
Ground	1.43±.04	.80	1.46±.12	.81	1.76±.05	.98
Grass	1.27±.07	.71	1.27±.07	.71	1.10±.01	.61
Forbs and bushes	1.71±.03	.95	1.68±.05	.94	1.47±.11	.82
Trees and buildings	0.90±.08	.50	1.03±.11	.57	0.76±.20	.42

Feeding Behavior

Of 45 nocturnal observations of adults feeding, 22 fed on mushrooms (both sexes of *P. pennsylvanica* and *P. virginica,* and females of *P. uhleriana*). Both sexes of *P. pennsylvanica* fed on mammalian, probably coyote, fecal matter ($N=8$), and a *P. uhleriana* female ate bird feces. *Parcoblatta lata* males and both sexes of *P. pennsylvanica* fed on sap from wounded trees ($N=8$), and a *P. lata* female ate the cambium layer from a wood chip. A *P. pennsylvanica* male consumed spittle from a cercopid nymph, and a *P. lata* female ate flower petals. A *P. uhleriana* male ate moss off of a tree trunk and a female of the same species fed on mammalian cartilage. The most unusual feeding observation was that of a *P. pennsylvanica* female attacking a weakened but upright and mobile *Camponotus pennsylvanicus* worker. The cockroach repeatedly bit the ant, sometimes picking it up and carrying it a short distance. The roach left and returned to the ant several times before moving away from the still living animal the final time. Rau (1940) noted an instance of predation by a female *P. pennsylvanica* on a *Polistes* larva.

Predators

Nine acts of predation on wood cockroaches were recorded, all but one on males. The predator was invariably a spider of the Thomisidae, Araneidae, or Agelenidae. On two occasions, mice *(Peromyscus leucopus)* were seen on a tree trunk with many cockroaches on it, possibly preying on them.

Interactions

Five *P. uhleriana* females feeding on a mushroom engaged in biting, kicking, lunging toward, and posturing when one contacted another. A *P. pennsylvanica* male pursued and drove off a *P. lata* male from flowing sap in a tree wound. Another *P. pennsylvanica* male drove off a *P. uhleriana* male that had antennated it. Once, a *P. pennsylvanica* male was forced away from a tree wound by foraging ants.

Seasonal Population Cycles

Adult male populations appeared at about the same time as adult female populations, but they were nearly extinct long before the female populations (Fig. 3). Population peaks for the two most common species, *P. pennsylvanica* and *P. uhleriana,* were distinct for both sexes. The bimodality of *P. bolliana* and *I. deropeltiformis* females was probably due to sampling error in rare populations.

Discussion

General Patterns of Species Distribution

Mobile animals arrange themselves in space by preferentially occupying particular parts of the environment. The pattern of distribution for a species is determined by such factors as the number of competing species encountered in a given area, the population densities of those species, availability of resources (food, refugia, etc.), and the number of predators, both absolute and relative. Insect populations may also have subtle temperature and humidity requirements for optimal growth rates (Edney et al., 1978).

The component species of the cockroach community in question showed considerable geographic variation in habitat choice. Lawson (1967) maintained that *P. bolliana* is "strictly a grassland species in Kansas," but 85.7% of the individuals I censused were found in the forest. The small numbers of this species observed, however, suggest that the area is suboptimal for this species. Both Lawson (1967) and Blatchley (1920) describe *I. deropeltiformis* and *P. lata* as forest species, but the demes I studied were primarily nonforest populations. I concur with both authors that *P. virginica* and *P. uhleriana* are forest species. *Parcoblatta virginica* was the most habitat-specific of the five

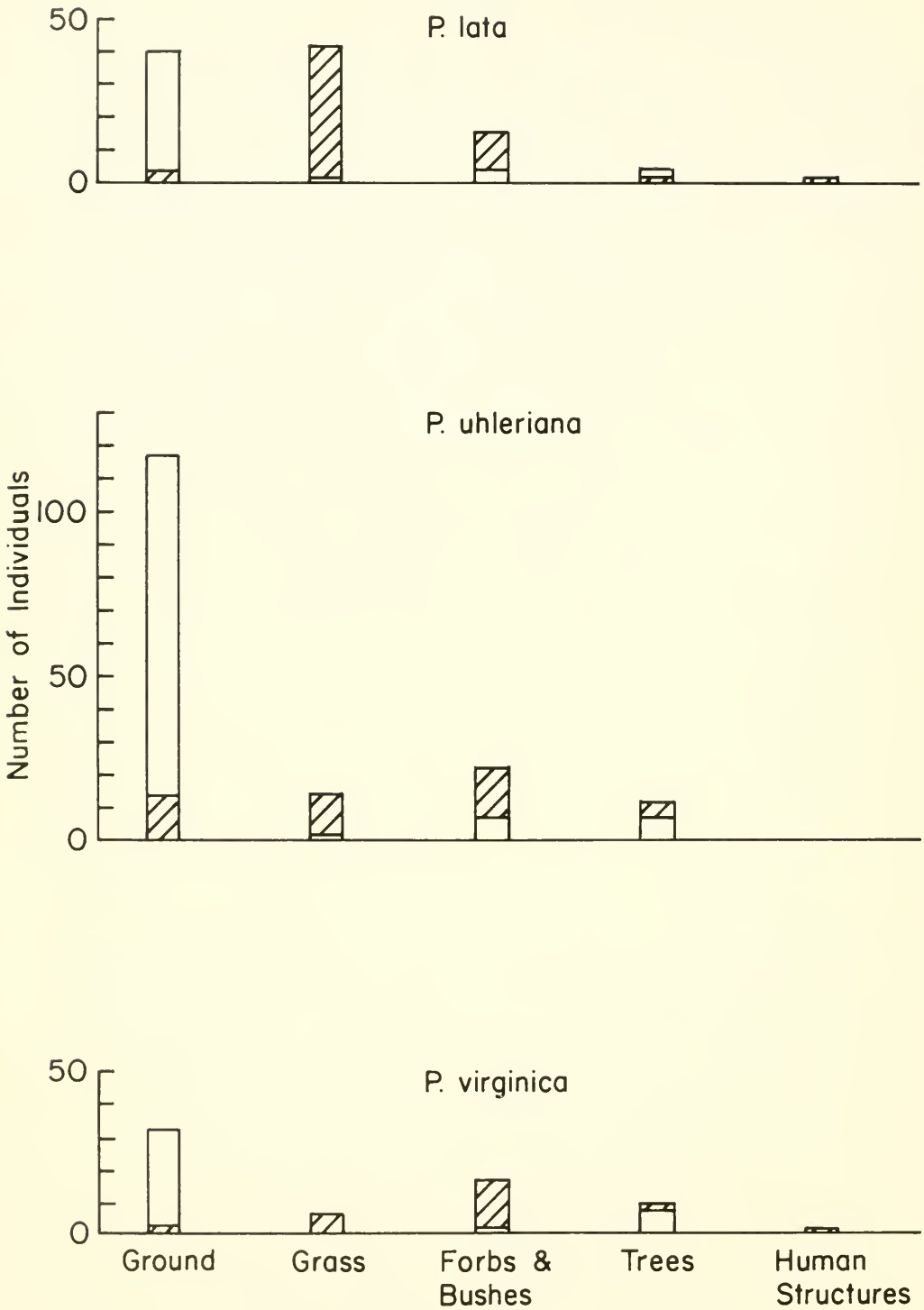
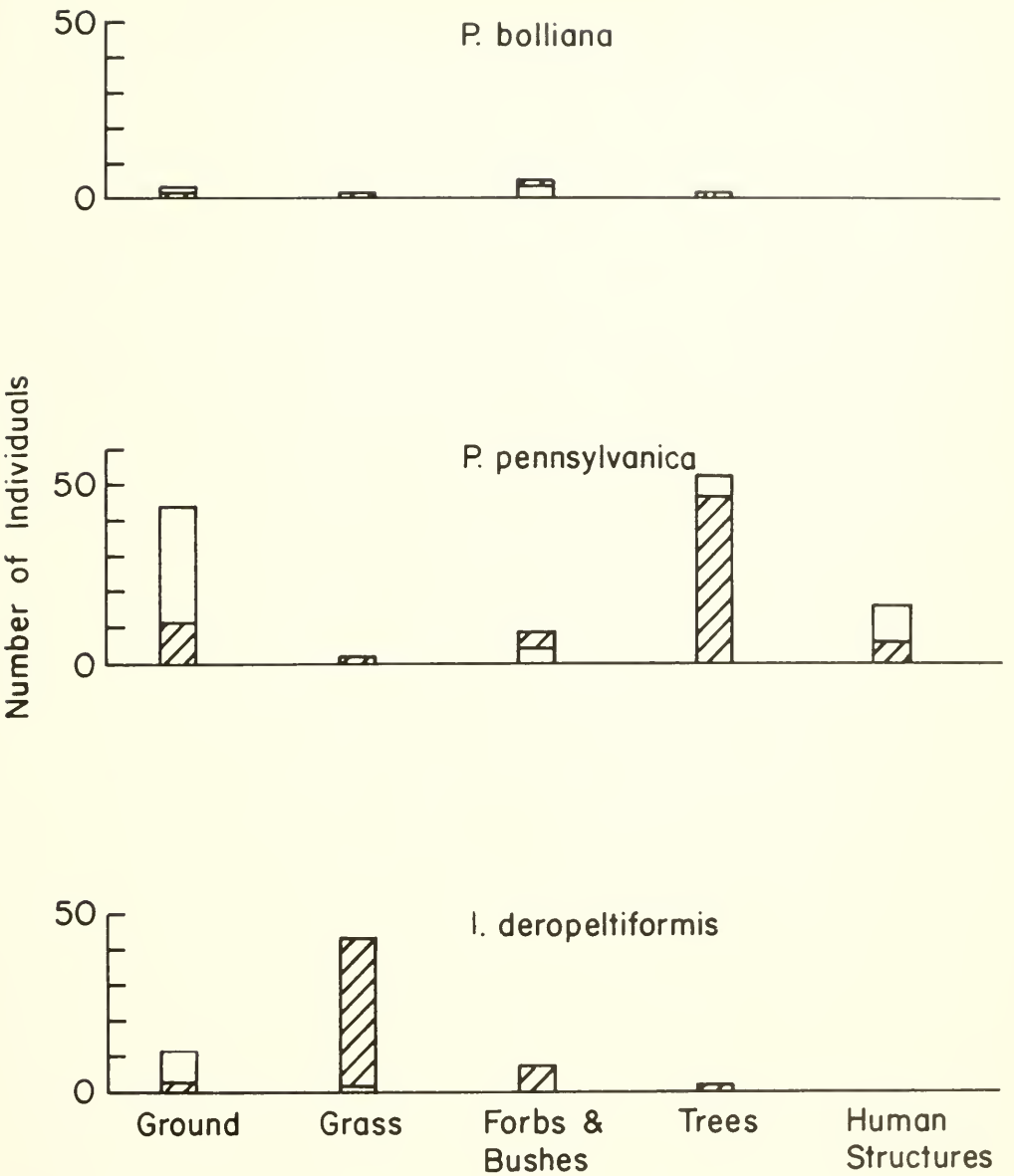


FIGURE 2. Bar graphs of substrates upon which cockroaches were found. Numbers of females are represented by open bars, males by hatched bars.



most common species, suggesting a species closely adapted to the forest environment. *Parcoblatta uhleriana* was the most abundant of the forest species, due either to higher fecundity or survival. Perhaps this species affects resource availability, thereby limiting forest populations of the other species. *Parcoblatta pennsylvanica* is a habitat generalist and a patch specialist, occurring wherever trees were found.

General Patterns of Species Diversity

Species diversity and evenness are characters of a community. These concepts derive from the fact that individuals are distributed among species differently in different parts of the environment. In the cockroach community, the same assemblage of species occurs in several different

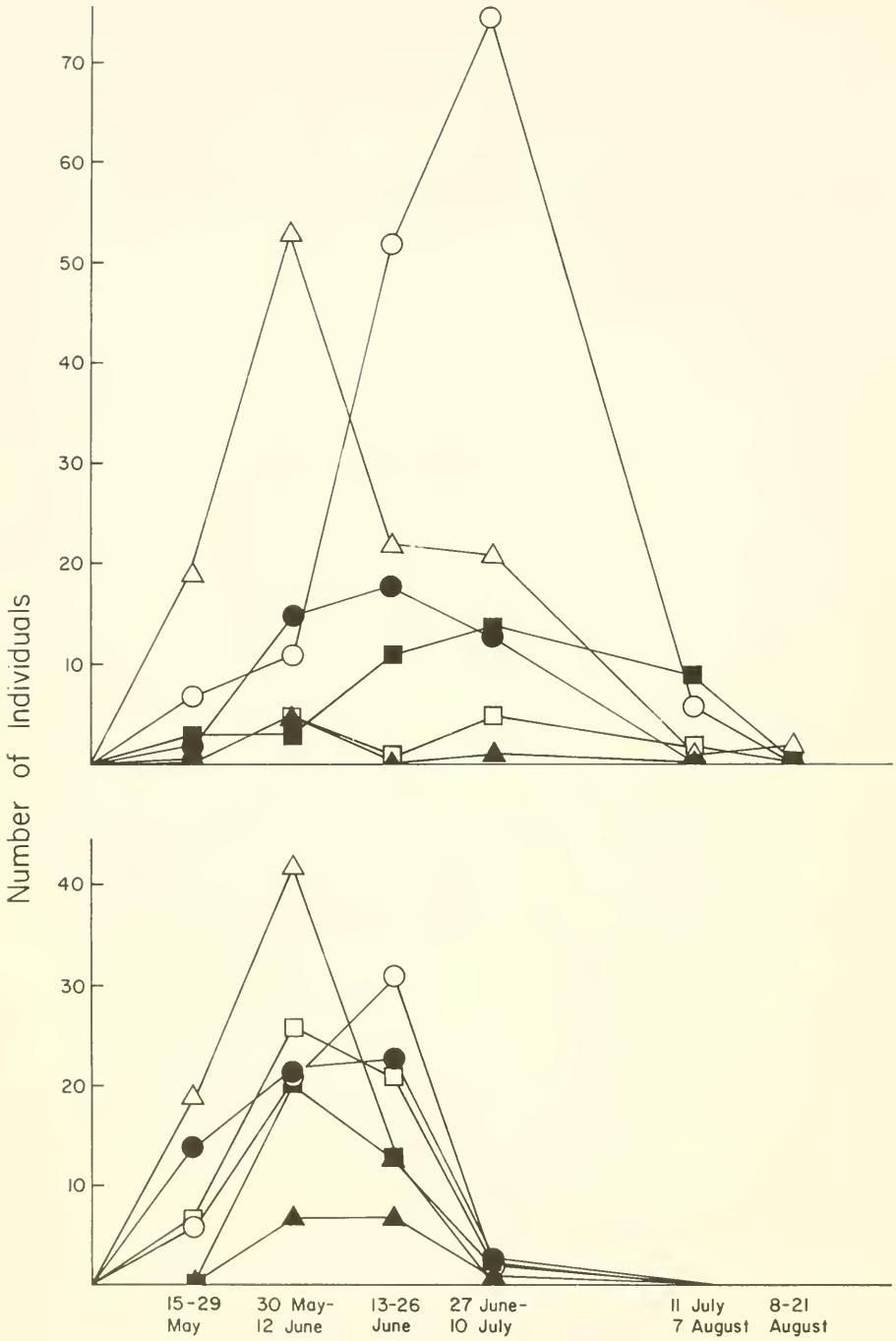


FIGURE 3. Seasonal population fluctuations of cockroaches. Above: females, Below: males.

combinations as a function of habitat and patch types (Table 4). Implicit in these measurements is the assumption that while individuals undoubtedly move freely from, say, the grass to a bush, the average overall species composition on *all* grasses and bushes is constant over time. (Also implicit, of course, is the assumption that the environmental partitions made by the investigator reflect those made by the organisms. Familiarity with the species assemblage investigated minimizes this source of error.)

One of the most remarkable results of this analysis is the perfect correlation between the species diversity found in the forest and nonforest habitats. A second very high correlation is that of the species diversity found on various patches when only species (not sexes) were considered and that found for the same patches for males. Males are, therefore, a good predictor of general species diversity in this community. Patterns of diversity vary in a systematic way between male and female components. These patterns differ by habitat and patch of maximum diversity, demonstrating preference for these parameters by species and sex.

Competition, Abundance, and Community Structure

Competition is a fundamental concept in ecology, yet ticklishly difficult to demonstrate directly, i.e., to actually *see* competition taking place at the population level (but see Roubik, 1978). Because the evidence for competition is often circumstantial, it is sometimes incorrectly invoked to explain population parameters (Wiens, 1977). Nevertheless, I believe there are several lines of circumstantial evidence implicating competition as an important determinant of cockroach community structure.

In the presence of competition, natural selection should operate to perpetuate those phenotypes displaying characters facilitating co-existence, resulting in nonrandom species arrangements in time and space. In the cockroach community, some species were much more abundant than others. The two commonest species, *P. pennsylvanica* and *P. uhleriana,* tended to occur in different parts of the environment and their population peaks (Fig. 3) were temporally staggered. *Parcoblatta pennsylvanica* was also the topmost species vertically and the most patch-specific species (Fig. 2). While patch choice did not differ for any species between forest and nonforest areas, there were five instances of different vertical distributions of at least one sex of a species as a function of general habitat (niche shifting). Females outlived males in each species, and intrasexual adult populations tended toward simultaneous extinction. In 2/3 of the species in this community, males were significantly higher on the vegetation than females. Finally, species showed overlap in food choices and some instances of direct behavorial interference. These similarities in food preferences and life expectancies and the differences in vertical and horizontal spatial distributions argue for intersexual, interspecific, and probably inter-lifestage competition as a factor influencing community structure.

The nymphs were impossible to distinguish to species in the field, so they could not be included in this study. They did, however, become increasingly abundant throughout the spring and summer until they were the only life stage observed. Nymphs were seen in the same places adults were observed, both at night and during the day when they were inactive, i.e., moving about on the vegetation and on the ground, and hiding under bark, manure, rocks, boards, and in and under rotting logs.

Generally, the adult cockroach community seems to exist at two distinct levels: females on or near the ground and males

above them on the vegetation, with copulating pairs in between. *Parcoblatta pennsylvanica* represents a third level above and rather isolated from the other two. Individuals at each level probably interact much more with each other than with those on other levels. The role of the nymphs in the community is difficult to assess, but undoubtedly has some impact.

ACKNOWLEDGMENTS

I thank C. D. Michener, K. B. Armitage, and especially W. J. Bell for constant encouragement and support. I also thank P. G. Decelles and L. M. Roth for reviewing the manuscript. Costs were defrayed by a Beamer Award for 1977 and again in 1978. This paper is part of a Doctor of Philosophy dissertation in Entomology from the University of Kansas.

LITERATURE CITED

BIRDSELL, R., and J. L. HAMRICK. 1978. The effect of slope-aspect on the composition and density of Oak-Hickory forest in eastern Kansas. Univ. Kansas Sci. Bull. 51:565-573.

BLATCHLEY, W. S. 1920. Orthoptera of North-eastern America. Indianapolis.

CONOVER, W. J. 1971. Practical Non-parametric Statistics. John Wiley, N.Y.

DREISIG, H. 1971. Diurnal activity in the Dusky Cockroach, *Ectobius lapponicus* L. (Blattodea). Entomol. Scand. 2:132-138.

EDNEY, E. B., P. FRANCO, and R. WOOD. 1978. The responses of *Arenivaga investigata* (Dictyoptera) to gradients of temperature and humidity in sands studied by tagging with Technetium 99m. Physiol. Zool. 51:241-255.

FRIAUF, J. J. 1953. An ecological study of the Dermaptera and Orthoptera of the Welaka area in northern Florida. Ecol. Monogr. 23:79-126.

GOULD, G. E., and H. O. DEAY. 1938. Notes on the bionomics of roaches inhabiting houses. Proc. Indiana Acad. Sci. 47:281-284.

———. 1940. The biology of six species of cockroaches which inhabit buildings. Bull. No. 451. Purdue Univ. Ag. Expt. Station. 31 p.

LAWSON, F. A. 1967. Ecological and collecting notes on eight species of *Parcoblatta* (Orthoptera: Blattidae) and certain other cockroaches. J. Kansas Entomol. Soc. 40:267-269.

MARTINKO, E. A. 1976. Seasonal changes in diversity of three adjacent insect communities. Ph.D. Dissertation. Univ. of Kansas, Lawrence.

PIELOU, E. C. 1969. An Introduction to Mathematical Ecology. John Wiley, N.Y.

RAU, P. 1940. The life history of the wood-roach, *Parcoblatta pennsylvanica* De Geer (Orthoptera: Blattidae). Entomol. News 51:4-9, 33-35.

ROUBIK, D. W. 1978. Competitive interactions between neotropical pollinators and Africanized honey bees. Science 201:1030-1032.

SOKAL, R. R., and F. J. ROHLF. 1969. Biometry. W. H. Freeman, San Francisco.

WIENS, J. 1977. On competition and variable environments. Amer. Sci. 65:590-597.

UNI
8124

MUS. COMP. ZOOL
LIBRARY
JUN 25 198
HARVARD
UNIVERSITY

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

TWO NEW SPECIES OF INQUILINOUS *MONOMORIUM* FROM NORTH AMERICA (HYMENOPTERA: FORMICIDAE)

By

Mark B. DuBois

Vol. 52, No. 3, pp. 31-37 June 12, 1981

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 3, pp. 31-37 June 12, 1981

Two New Species of Inquilinous *Monomorium* from North America (Hymenoptera: Formicidae)

Mark B. DuBois

Department of Entomology, University of Kansas, Lawrence, Kansas 66045

Contents

Abstract 31
Introduction 31
Monomorium talbotae new species 31
Monomorium inquilinum new species 34
Monomorium (=*Epoecus*) *pergandei* lectotype designation 36
Key to North American inquilinous *Monomorium* 36
Acknowledgments 37
Literature Cited 37

Abstract

The ant, *Monomorium talbotae,* new species, is described from Michigan. This species is compared briefly with *Monomorium pergandei.* Dealate and alate females and males were found in three colonies of a host species which is the *M. minimum* of Talbot (1975). This new ant is apparently a workerless, permanent social parasite.

Similarly, another workerless, permanent social parasite, *M. inquilinum,* is described from Mexico and compared with *M. pergandei* and *M. talbotae.* One female was discovered in a nest of what is, or is closely related to, *M. cyaneum.*

Both inquilinous species are compared with their hosts and a key is provided for the separation of the inquilinous *Monomorium.* The taxonomic relationships between hosts and inquilines are also discussed.

A lectotype is designated for *M. pergandei.*

Introduction

Although several species of parasitic *Monomorium* have been described from around the world, only two species have been described as inquilines of *Monomorium (minutum* group) in North America. Since Ettershank (1966) synonymized *M. metoecus* (Brown and Wilson, 1957) with *M. minimum* because of the existence of a worker caste (Wilson and Brown, 1958), *M. pergandei* (Emery, 1892, described further 1895) has been the only known inquilinous *Monomorium* in North America.

Recently, I received specimens of two new species of inquilinous *Monomorium: M. talbotae* from Michigan (courtesy of Dr. Mary Talbot) and *M. inquilinum* from Mexico (courtesy of Ms. Margaret Thayer at the Museum of Comparative Zoology). *Monomorium talbotae* is known from the holotype, allotype, and eight paratypes. *Monomorium inquilinum* is known only from the holotype.

Monomorium talbotae New Species

Holotype female and allotype male.— MICHIGAN: Livingston Co.; E. S.

George Reserve; 30 June 1966; M. Talbot (66-13). Holotype and allotype are deposited in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Holotype lacks left forewing and right hindwing. Paratypes are in the following collections: M. B. DuBois personal collection (2 females); Snow Entomological Museum, University of Kansas, Lawrence (1 female); M. Talbot personal collection (4 females, 1 male).

Female

Diagnosis.—Similar to *M. pergandei* in general morphology and lack of a worker caste, but differing in the following features: clypeus scarcely emarginate, lacking teeth; propodeum, petiole and postpetiole as in Figure 1; no depression on first gastral tergum.

Similar to host in general morphology but differing in the following features: worker caste lacking; clypeus scarcely emarginate; mandible with two teeth; length less than 3 mm.

Description.—Habitus, in general, like queens of other *Monomorium* (Fig. 1). Total length including mandibles 2.28 mm in alcohol. HEAD: Length 0.45 mm; width 0.43 mm; surface smooth and shining with pits (representing insertions of setae) prominent; mandible with two teeth; maxillary palp 1-segmented; labial palp 1-segmented; clypeus scarcely emarginate, lacking teeth; antenna 12-segmented with a weakly developed 3-segmented club. Head and mandibles light brown, antennae light yellow. ALITRUNK: Length 0.68 mm; pronotal width 0.33 mm; surface smooth and shining with pits prominent on pronotum; propodeal spines absent. Alitrunk light brown, legs light brown except tibiae and tarsi which are light yellow. Wings as in Figure 1. PETIOLE: Length 0.21 mm; width 0.16 mm; height 0.23 mm; pedunculate; dorsal surface of node evenly convex with no trace of emargination; both anterior and posterior surfaces of node evenly covered with erect setae of uniform height; sides of petiole smooth. Color light brown. POSTPETIOLE: Length 0.13 mm; width 0.23 mm; height 0.18 mm; dorsal surface of node evenly convex with no trace of emargination; sides of postpetiole punctate. Color light brown. GASTER: No depression on first gastral tergum; surface of gaster smooth and shining with pits visible on first tergum. Color light brown.

Worker

Unknown and apparently non-existent, as in *M. pergandei.*

Male

Description.—Habitus, in general, like males of other *Monomorium.* Total length including mandibles 2.18 mm in alcohol. HEAD: Length 0.43 mm; width 0.43 mm; antenna with 12 segments; sculpture, palps and color as in holotype. Mandible reduced, similar to female. ALITRUNK: Length 0.68 mm; pronotal width 0.29 mm; sculpture, propodeum, and color as in holotype. Wings as in Figure 1. PETIOLE: Length 0.20 mm; width 0.15 mm; height 0.16 mm; pedunculate; dorsal surface, pilosity, sculpture and color as in holotype. POSTPETIOLE: Length 0.13 mm; width 0.23 mm; height 0.15 mm; pilosity, sculpture and color as in holotype.

Variation

The following measurements, in millimeters, were taken from the holotype, seven paratype females and one paratype male. All measurements were made in alcohol. Variation within each character measured for the females is expressed as the mean (range). The actual measurements for the male specimen are given in

brackets following the measurements of the females. HEAD: Length 0.44 (0.40-0.48) [0.39]; width 0.40 (0.39-0.42) [0.42]. ALITRUNK: Length 0.68 (0.63-0.72) [0.63]; pronotal width 0.32 (0.27-0.33) [0.30]. PETIOLE: Length 0.18 (0.10-0.21) [0.16]; width 0.16 (0.15-0.18) [0.18]; height 0.20 (0.18-0.23 [0.19]. POSTPETIOLE: Length 0.11 (0.09-0.14) [0.10]; width 0.20 (0.19-0.23) [0.21]; height 0.16 (0.15-0.21) [0.15]. TOTAL LENGTH: 2.32 (2.10-2.55) [2.33].

Derivatio nominis

This species is named after Dr. Mary Talbot, who discovered it.

Habitat

From notes by M. Talbot: "A high, dry field where vegetation was not dense and small patches of bare sandy soil were numerous. Grassess were mostly *Poa compressa* and *Aristida* sp. A variety of scattered forbs included *Lespedeza capitata, Liatris aspersa, Rumex acetosella,* and *Solidago* spp. Patches of *Polytrichum piliferum* moss were large and frequent, and the red-tipped lichen, *Cladonia cristalella* var. *vestita,* was characteristic."

Comparison of M. talbotae *with its Host*

Wilson (1971, p. 374-5) cites a set of morphological and behavioral characteristics which are found in some combination in all species of inquilinous ants. Several of these traits can be recognized in *M. talbotae* (numbers of traits correspond to those of Wilson): 1. worker caste is lost; 4. female and male are reduced in size; 8. although the arrangement of veins is similar to that of the host, many of these "veins" are represented as the absence of microtrichia (dashed lines in figures), indicating a reduction in venation; 9. mouthparts are reduced, with the mandible losing two teeth and the labial and maxillary palps losing one segment each; 13. petiole and postpetiole are thickened; 14. a spine is formed on the ventral surface of the postpetiole; and 16. cuticular sculpturing is reduced. One additional character which is probably associated with small size is the reduction in size and complexity of the male genitalia.

In spite of the above modifications, *M. talbotae* appears to be closely related to its host for the following reasons. 1. Although the wing veins are reduced in *M. talbotae,* their placement is nearly identical with the placement of veins in the host's wings. 2. The reduced male genitalia are more similar to those of the host than to any other North American *Monomorium*. The structure of sternum VIII is correspondingly similar. Sternum IX is also similar, although it has been reduced to such an extent that it resembles the corresponding structure in most North American *Monomorium*. 3. The metanotum is present as a small bump in side view (Fig. 1). This is true for both *M. talbotae* and its host. However, the metanotum is shaped differently in *M. inquilinum* (Fig. 2). 4. The propodeum is of a similar rounded shape in both *M. talbotae* and its host (Fig. 1). This can be compared with the flattened outline of the propodeum in *M. inquilinum* (Fig. 2). 5. The suture across the mesothorax is evenly curved and slightly thickened at the posterior end in both *M. talbotae* and its host (Fig. 1). 6. The pilosity of *M. talbotae* is more similar to its host than to *M. inquilinum*.

Measurements of host queen.—The following measurements were taken from a queen of the *M. minimum* of Talbot (1975) collected from the E. S. George Reserve. Total length including mandibles 5.20 mm in alcohol. HEAD: Length 0.75 mm; width 0.8 mm. ALITRUNK: Length 1.45 mm; pronotal width 0.7 mm. PETIOLE: Length 0.50 mm; width 0.30

mm; height 0.38 mm. POSTPETIOLE: Length 0.25 mm; width 0.38 mm; height 0.33 mm.

Measurements of host male.—The following measurements were taken from a male of the *M. minimum* of Talbot (1975) collected from the E. S. George Reserve. Total length including mandibles 4.86 mm in alcohol. HEAD: Length 0.72 mm; width 0.81 mm. ALITRUNK: Length 1.59 mm; pronotal width 0.78 mm. PETIOLE: Length 0.51 mm; width 0.27 mm; height 0.36 mm. POSTPETIOLE: Length 0.21 mm; width 0.31 mm; height 0.33 mm.

Monomorium inquilinum NEW SPECIES

Holotype label data.—Estado de Mexico: Highway 57 (between Mexico City and Queretaro), km 127 (measured from Mexico City); 9 August 1965; High Desert; Cornell University Mexico Field Party. W. L. Brown (pers. comm.) indicated that his field notes record the locality as 83 km south of Queretaro. Holotype is deposited in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Wings lacking on holotype although specimen appears to have possessed them when younger.

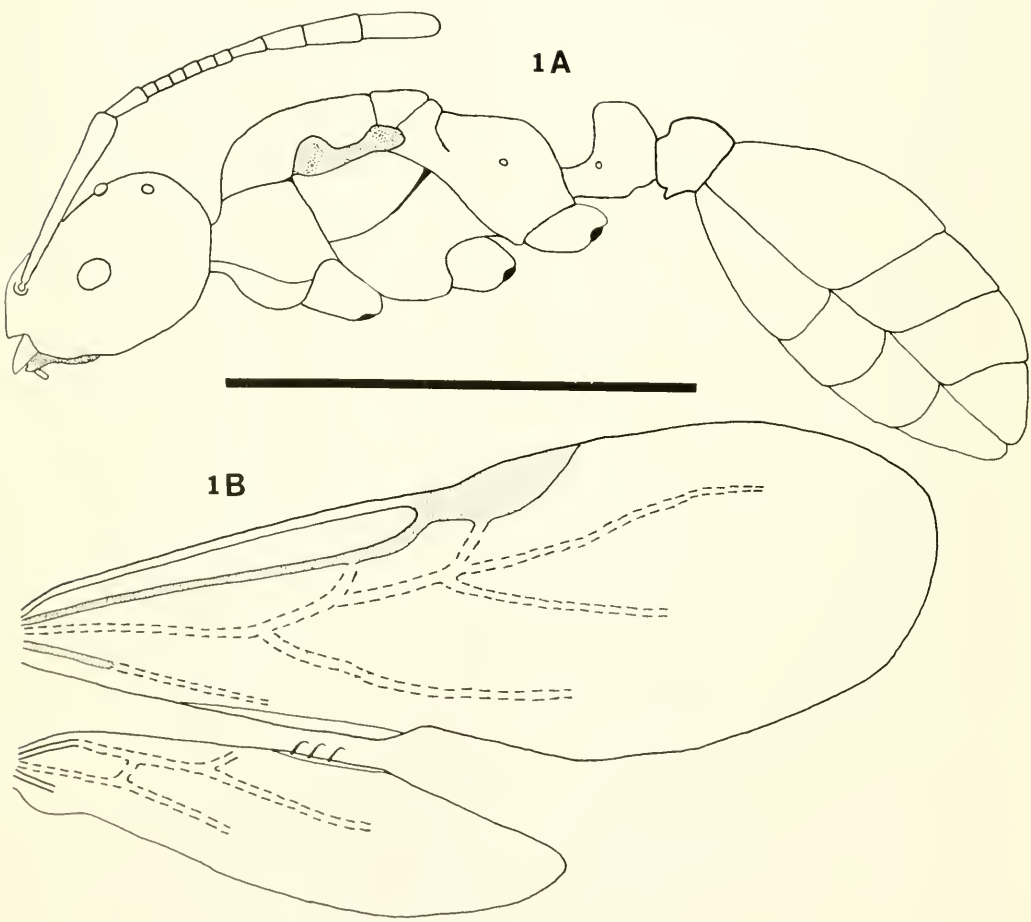


FIGURE 1. *Monomorium talbotae*, female. A. Side view showing outline and major sutures (legs omitted). Stippling indicates membranous areas. B. Wings. Stippling indicates most heavily sclerotized veins. Dashed lines indicate veins represented by lack of microtrichia. Both A and B drawn to same scale. Line equals 1 mm.

Female

Diagnosis.—Similar in general morphology to *M. pergandei* but differing in the following features: clypeus emarginate but lacking distinct carinae or teeth; anterior edge of pronotum rounded in side view vs. angular projecting edge in *M. pergandei* (Figs. 2 and 3); dorsum of petiolar node emarginate. Similar to *M. talbotae* but differing in the following features: first gastral tergum with slight basal depression; metanotum with outline as in Figure 2; dorsum of both petiole and postpetiole emarginate; outline of propodeum as in Figure 2; and dorsum of alitrunk with pilosity of uniform distribution and length.

Description.—Habitus similar to that of *M. pergandei* (Fig. 2). Total length including mandibles 2.16 mm dry. HEAD: Length 0.45 mm; width 0.39 mm; surface smooth and shining; mandible with two teeth; maxillary palp 1-segmented; labial palp 2-segmented; clypeus emarginate but lacking distinct teeth; frontal groove extends to level of anterior ocellus; antenna 12-segmented with weakly developed 3-segmented club. Head and mandibles dark brown, antennae yellow. ALITRUNK: Length 0.66 mm; pronotal width 0.30 mm; surface smooth and shining; propodeal spines absent. Alitrunk dark brown, tibia and tarsi yellow. PETIOLE: Length 0.20 mm; width 0.16 mm; height 0.21 mm; pedunculate; dorsal surface of node emarginate; both anterior and posterior surfaces evenly covered with erect setae; sides of petiole smooth to weakly punctate. Color brown. POSTPETIOLE: Length 0.09 mm; width 0.24 mm; height 0.18 mm; dorsal surface of node emarginate; sides of postpetiole punctate. Color brown. GASTER: Small depression at base of first gastral tergum; surface of gaster smooth and shining. Color brown.

Derivatio nominis

This name is used in reference to the inquilinous way of life of this ant as indicated by the association with *M. cyaneum* and the lack of a worker caste.

Habitat

From notes by W. L. Brown, Jr.: This specimen came from a populous colony of *M. cyaneum* (?) under a rock in plateau semidesert with low shrubs.

Comparison of M. inquilinum *with its Host*

Monomorium inquilinum has many of the morphological characters found in inquilinous ants (Wilson, 1971) which were discussed with the previous species. Since the holotype lacks wings, it is unknown whether the wing venation is reduced.

In spite of these modifications, *M. inquilinum* appears to be closely related to its host for the following reasons (numbers correspond to previous comparison of *M. talbotae* with its host). 3. The outline of the metanotum, in side view, is similar between *M. inquilinum* and its host. 4. The shape of the propodeum is similar between these two species. 6. The pilosity of both species is similar.

One difference between *M. inquilinum* and its host is that *M. inquilinum* presumably possessed wings as a young female while *M. cyaneum* (?) queens did not (based on the fusion of sclerites). This is difficult to interpret since there is such a small sample of queens of both species from this locality.

Measurements of host queen.—The following measurements were taken from a queen of what is, or is closely related to, *M. cyaneum* collected at the same locality as *M. inquilinum*. Total length including mandibles 4.7 mm dry. HEAD: Length

0.85 mm; width 0.75 mm. ALITRUNK: Length 1.30 mm; pronotal width 0.55 mm. PETIOLE: Length 0.45 mm; width 0.35 mm; height 0.40 mm. POSTPETIOLE: Length 0.20 mm; width 0.40 mm; height 0.35 mm.

Monomorium pergandei LECTOTYPE DESIGNATION

Originally described as *Epoecus pergandei* by Emery (1892, 1895), Ettershank (1966) placed this species in *Monomorium*. Although several museums contain syntypes of this species, the lectotype was selected from specimens in the National Museum of Natural History, since Pergande collected this species, and most of his collection is deposited there.

Lectotype female.—DISTRICT OF COLUMBIA: Washington;7-12/ [Next label illegible, ending in 206]/ No. 53581 U.S.N.M. Cotype/ [Handwritten label] *Epoecus pergandei* (type) Emery.

Lectotype is in good condition possessing all legs, antennae and wings. In addition to this type, the U.S.N.M. contains four paralectotypes (1 badly damaged) and the Museum of Comparative Zoology contains two additional paralectotypes (1 badly damaged). All specimens examined are females and now possess red, handwritten labels indicating lectotype or paralectotype.

KEY TO NORTH AMERICAN INQUILINOUS *Monomorium*

The following key will provide for the separation of all three species of inquilinous *Monomorium* occurring in North America. All these species would key to *Epoecus pergandei* in Creighton (1950).

1. Base of first gastral tergum with dorsal impression 2

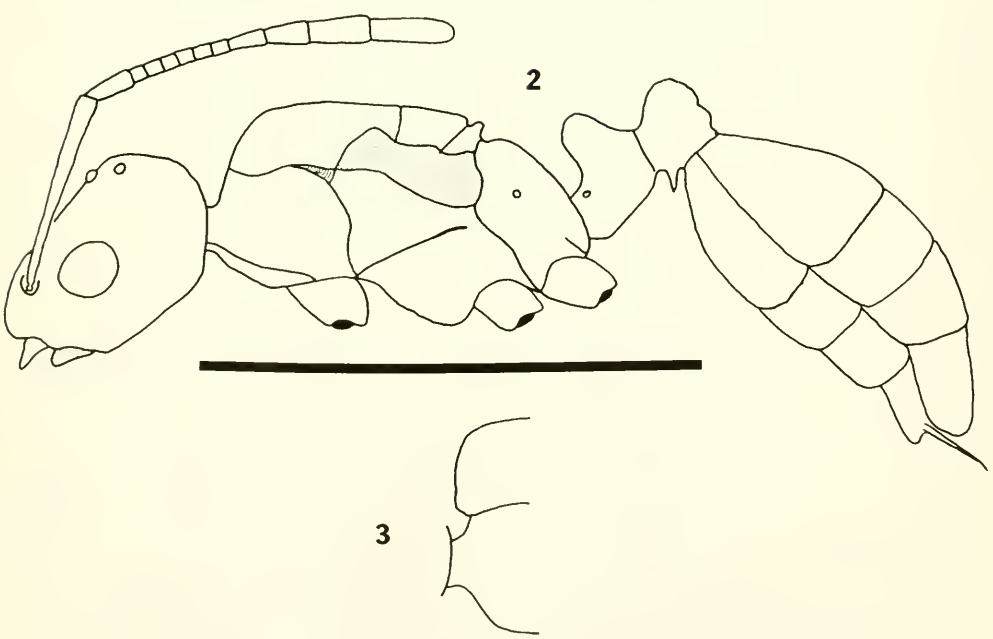


FIGURE 2. *Monomorium inquilinum*, female. Side view showing outline and major sutures (legs omitted). Stippling indicates membranous areas. Line equals 1 mm.

FIGURE 3. *Monomorium pergandei*, female. Side view of anterior prothorax indicating projecting pronotum. Line equals 1 mm.

Base of first gastral tergum lacking dorsal impression ..... *Monomorium talbotae*

2. Anterior edge of pronotum as in Figure 3 ..... *Monomorium pergandei*
   Anterior edge of pronotum as in Figure 2 ..... *Monomorium inquilinum*

Acknowledgments

I wish to thank Dr. C. D. Michener for criticizing this manuscript and supplying many useful suggestions, Dr. Mary Talbot for providing specimens of *M. talbotae*, Ms. M. Thayer for supplying *M. inquilinum*, and Drs. R. McGinley (M.C.Z.) and D. R. Smith (National Museum of Natural History) for allowing me to examine the cotypes of *M. pergandei*.

This work was supported, in part, by a grant-in-aid of research from the Society of Sigma Xi.

Literature Cited

Brown, W. L. and E. O. Wilson. 1957. A new parasitic ant of the genus *Monomorium* from Alabama, with a consideration of the status of genus *Epixenus* Emery. Entomol. News 68:239-246.

Creighton, W. S. 1950. The ants of North America. Bull. Mus. Comp. Zool. Harvard Univ. 104:1-585.

Emery, C. 1892. [No Title] Soc. Ent. de France, Bul. 61: cclxxv-cclxxvii.

——— 1895. Beiträge zur Kenntnis der nordamerikanischen Ameisenfauna. Zoolog. Jarhb. Abtheilung fur Systematik, Geographie und Biologie 8:257-360.

Ettershank, G. 1966. A generic revision of the world Myrmicinae related to *Solenopsis* and *Pheidologeton* (Hymenoptera: Formicidae). Australian J. Zool. 14:73-171.

Talbot, M. 1975. A list of the ants (Hymenoptera: Formicidae) of the Edwin S. George Reserve, Livingston County, Michigan. Great Lakes Entomol. 8:245-246.

Wilson, E. O. 1971. The Insect Societies. Belknap Press, Harvard Univ., Cambridge. 548 pp.

Wilson, E. O. and W. L. Brown, Jr. 1958. The worker caste of the parasitic ant *Monomorium metoecus* Brown and Wilson, with notes on behavior. Entomol. News 69:33-38.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

SOME EFFECTS OF SELENIUM, VANADIUM AND ZIRCONIUM ON THE SWIMMING RATE OF *TETRAHYMENA PYRIFORMIS:* A BIOASSAY STUDY

By

Eugene C. Bovee and Timothy L. O'Brien

Vol. 52, No. 4, pp. 39-44 December 21, 1982

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 4, pp. 39-44 December 21, 1982

Some Effects of Selenium, Vanadium and Zirconium on the Swimming Rate of *Tetrahymena pyriformis*: a Bioassay Study*

Eugene C. Bovee and Timothy L. O'Brien[1]

Department of Physiology and Cell Biology, University of Kansas, Lawrence, Kansas 66045

Abstract

By stroboscopic photography, the swimming rate of *Tetrahymena pyriformis* strain HSM was measured in aqueous solutions of each of three metallic substances: Selenium as selenous acid (H_2SEO_3); vanadium as vandyl sulfate ($VOSO_4 \cdot 2H_2O$); and zirconium as zirconyl chloride ($ZrOCl_2 \cdot 6H_2O$). Swimming rate was measured over 45 min periods, monitored each 15 min, in concentrations of each metal, singly, at 0, 5, 10, 20, and 30 and 50 ppm. Significant decrease in swimming rate was recorded for each metal at concentrations of 20 ppm or more. The method provides a useful bioassay to determine the presence of pollutants in freshwater, quickly and easily.

Some recent studies (Cooley et al., 1972; Carter and Cameron, 1973; Bergquist, 1974; Bergquist and Bovee, 1976; Bovee et al., 1977; Bovee et al., 1979) indicate that measurement of the swimming rate and/or growth rate of *Tetrahymena pyriformis*[2] can be used to bioassay the amount of a pollutant in water if the pollutant is known, or to identify the generally toxic level of pollutants in a freshwater source. Other species of Protozoa may also serve as indicators of toxic levels of pollution, including *Amoeba proteus, Euglena gracilis* and *Paramecium caudatum* (Mills, 1973), *Stentor coeruleus* and *Vorticella campanula* (Burbanck and Spoon, 1967), and populations of Protozoa (Lackey, 1938, 1968; Bovee, 1965; Sunderasen et al., 1965; Bick, 1973; Cairns, 1973; Ruthven and Cairns, 1973; Small, 1973).

Selenium, vanadium and zirconium are becoming important pollutants in water sources, due to their escape from industrial processes, from the burning of fossil fuels and, more recently, from their appearance in insecticides destined to replace the polychlorinated hydrocarbons and organophosphates.

There is evidence that those metals are toxic to vertebrates, including humans, in amounts greater than 20 parts per million in water or in foodstuffs (Hathcock et al., 1964).

Therefore, we measured the swimming rates of *Tetrahymena pyriformis* in various concentrations of those metals in water, singly, to determine if such measurements might serve as a bioassay to detect toxic and subtoxic amounts of those metals.

* Supported by Kansas Water Resources Institute Matching Grants A-058 and B-040 and, in part, by NSF Grant GB-16616.

[1] Present address: Electronmicroscopy Center, University of Illinois, Urbana, Illinois 61801.

[2] The specific identity of this strain is not known in relationship to the species of *Tetrahymena* named by Nanney and McCoy (Trans. Amer. Microscop. Soc. 95:664-682 [1976]). It is generally considered to be, as indicated, a strain of *Tetrahymena pyriformis*.

MATERIALS AND METHODS

Tetrahymena pyriformis (strain HSM) were grown at 22° C in 2% proteose-peptone (Difco), 0.1% sodium acetate ($CH_3COONa \cdot 3H_2O$) and 0.1% sodium phosphate (Na_2HPO_4) dissolved in Chalkley's solution (Chalkley, 1930) at pH 6.9-7.0.

Freshly prepared test solutions were made up in Chalkley's solution and were used for each day's experiments, so that organisms were exposed in one of the following concentrations during a period of 45 min; 0, 5, 10, 20, 30 or 50 ppm of each metal. Selenium solutions were prepared from selenous acid (H_2SeO_3); vanadium from vanadyl sulfate ($VOSO_4 \cdot 2H_2O$); and zirconium from zirconyl chloride ($ZrOCl_2 \cdot 6H_2O$). The pH of each solution was adjusted for each experiment so that in the testing it was maintained at pH 7.0 ± 0.1.

For stroboscopic photography the apparatus was a binocular, Zeiss-Nomarski, research model, phase-contrast microscope with phototube on which a 35 mm Zeiss camera was mounted. An aluminum disc with two one-inch holes 180° from one another at the periphery was mounted on the chuck of a variable-speed laboratory stirring motor and was set so that the disc rotated between the light source (a research model microscope lamp) and the

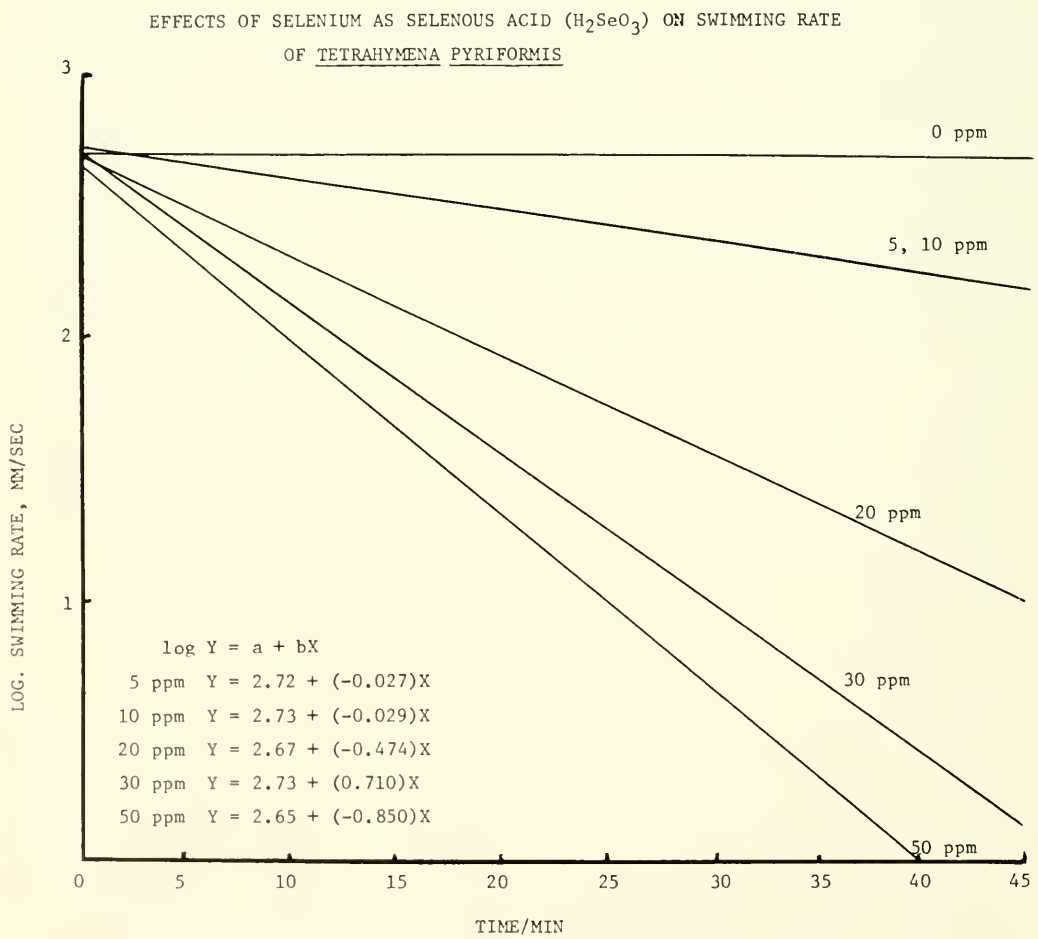


FIG. 1. Effects of selenium on the swimming rate of *Tetrahymena pyriformis*.

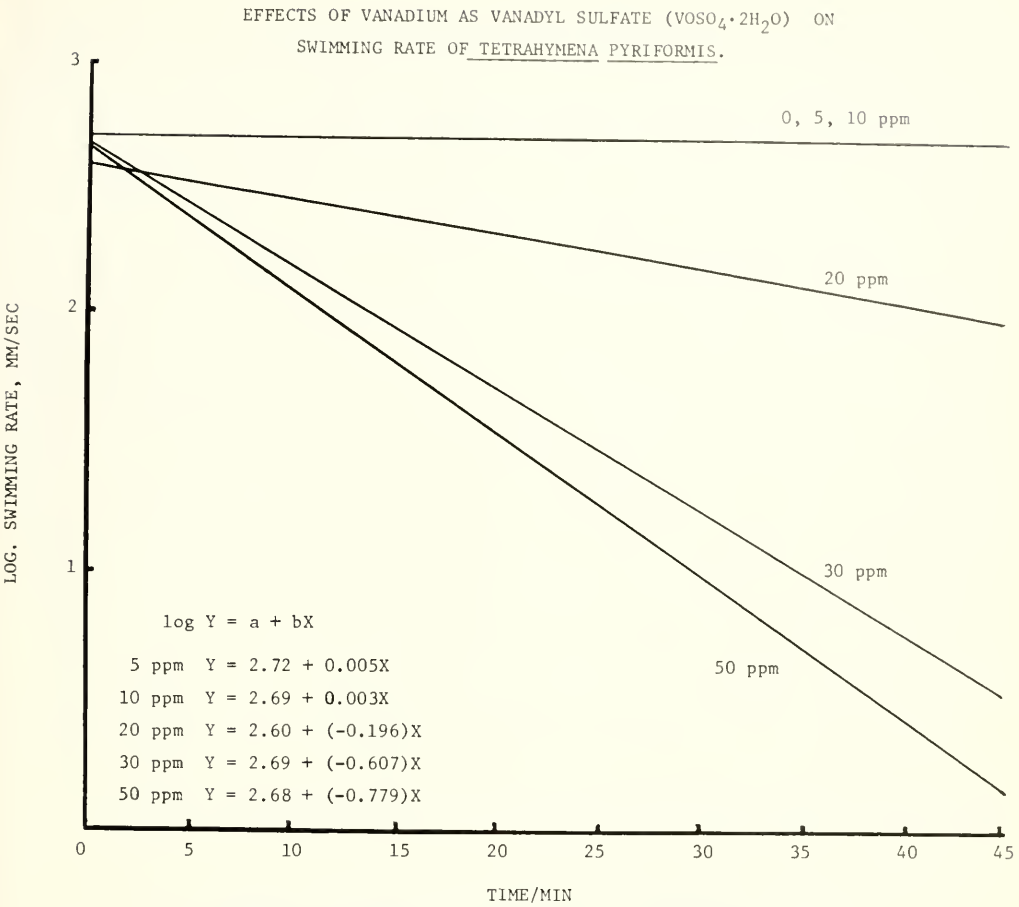


FIG. 2. Effects of vanadium on the swimming rate of *Tetrahymena pyriformis*.

reflecting prisms of the microscope. The rotating disc thus delivered pulsed light at a preset rate/sec to maximize the distance between images on the film. The apparatus delivered pulsed light with an accuracy to 0.01 sec.

Photographs were taken of groups of *Tetrahymena* swimming at 63X or 100X magnification under darkfield illumination, achieved by adjusting the phase condensor system. The first was taken as soon as the *Tetrahymena* were placed on the microscope and the focus adjusted. This is designated as "zero" time and five photographs were taken within one minute. The light was turned off, then on again at 15 min and another five photos taken. The procedure was repeated at 30 min and 45 min. Distances between the images were measured from the rear of one to the rear of the next forward. Measurements were made on projections of the images onto a viewing screen at total magnification of 1200X to eliminate as much error of measurement as possible. Five measurements were made for each organism and ten organisms were measured for each time period with mean rate calculated from the 50 measurements. Regression line plots were determined for each control and experimental set of data acquired for each concentration (Sokol and Rohlf, 1969).

Prior to experimentation, about 10 ml of a 1-2 day old culture of *Tetrahymena* in mid log-phase growth (about 200,000

cells per ml) was concentrated by centrifugation at 1550 rpm for 15 min, the supernatant discarded and the cells resuspended in Chalkley's solution and washed, then reconcentrated by centrifugation and transferred to Chalkley's solution in a holding chamber (Bergquist and Bovee, 1976) where the solution was stirred continuously. The pH of the solution in the holding chamber was checked at intervals and, if necessary, was adjusted with either HCl or NaOH solution to pH 7.0.

Organisms to be measured for swimming rate were pipetted from the holding chamber into a drop of the test solution on a clean glass microscope slide and were covered with a glass cover slip sealed peripherally with medically pure petroleum jelly. They remained thus during the experiment. The amount of fluid pipetted with the organisms was taken into consideration, so that the organisms were exposed to the desired concentration of the metal being used.

Results of Experiments

Swimming rates of controls.—The swimming rates of controls were unaffected by the Chalkley's solution or by changes of temperature from 22° to 27°C during continuous exposure to the light of the microscope. The pH did not affect swimming rate in the range of 6.9 to 7.1. Control rates of swimming were close to

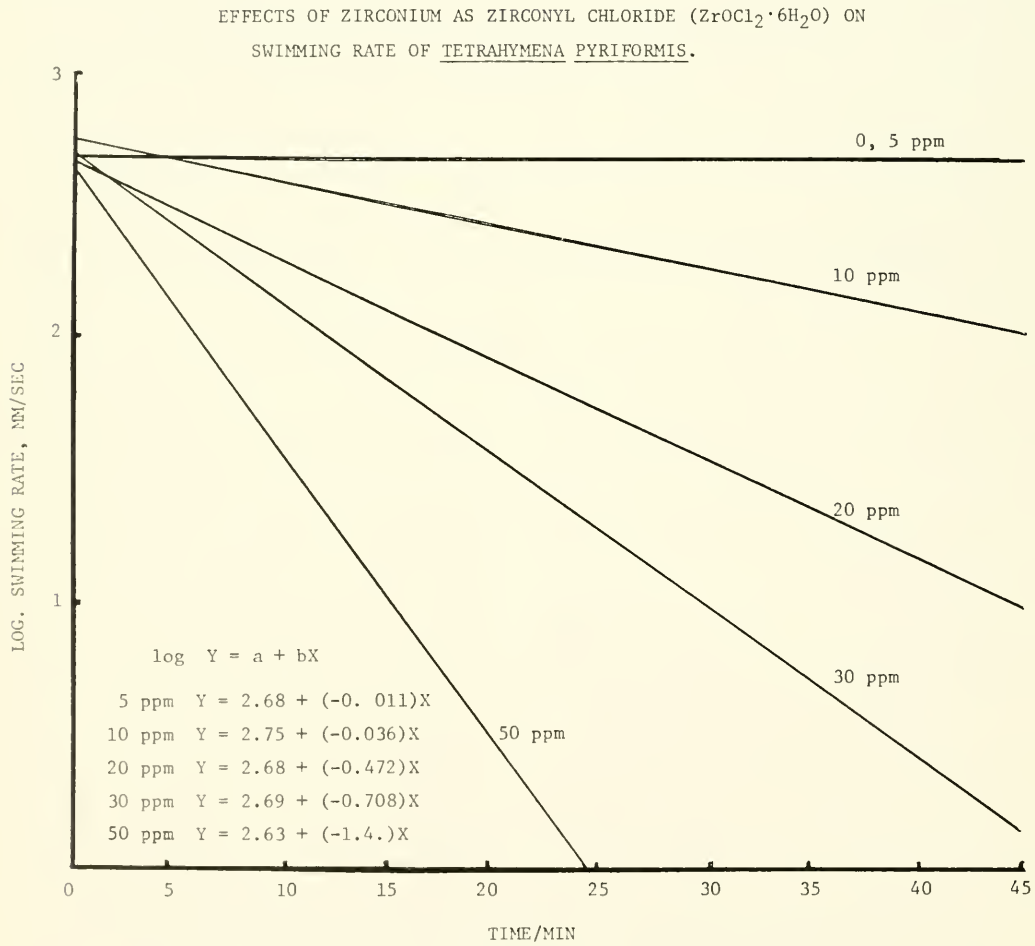


FIG. 3. Effects of zirconium on the swimming rate of *Tetrahymena pyriformis*.

2700 μm/sec without significant variation, during the 45 min of testing.

Swimming rates in selenium.—Regression line plots of the data for effects of selenium on the swimming rate showed a decrease of rate from 2700 μm/sec to 2200 μm/sec (18.5%) after 45 min in either 5 or 10 ppm. At 20 ppm the rate decreased to ~ 1000 μm/sec (62.9%); at 30 ppm the rate decreased to ~ 35 μm/sec (98.6%); and at 50 ppm the organisms stopped swimming after ~ 40 min (Fig. 1).

Swimming rates in vanadium.—Vanadium had no effect on swimming rate within 45 min at 5 or 10 ppm. At 20 ppm the rate decreased to ~ 2000 μm/sec (29.6%); at 30 ppm it decreased to ~ 520 μm/sec (80.7%); at 50 ppm, to ~ 75 μm/sec (97.2%) (Fig. 2).

Swimming rates in zirconium.—At 5 ppm zirconium did not affect swimming rate. At 10 ppm the rate decreased to ~ 2200 μm/sec (18.5%); at 20 ppm, to ~ 1000 μm/sec (62.9%); at 30 ppm, to ~ 70 μm/sec (97.4%). The organisms stopped swimming in ~ 24 min at 50 ppm (Fig. 3).

From these results it is clear that the swimming rates are significantly affected by any concentration of these metals greater than 10 ppm under the conditions of experiment.

Discussion

Trace amounts of selenium (Cunja, 1973) or of vanadium (Weast, 1970) in the diet are stimulatory to the growth of vertebrates, as well as to *Tetrahymena pyriformis* (Tippitt, 1975; Schreiber, 1978). Amounts greater than 10 ppm are detrimental to vertebrates if continued over a period of time (Muhler, 1957; Niimi and Leham, 1976) or to the growth of *Paramecium* (Stanton et al., unpubl.) or of *Tetrahymena* (Tippitt, 1975; Schreiber, 1978; Makinde, 1979). Either may become concentrated in vertebrate tissues to toxic levels, especially in kidney, liver and spleen (Hathcock et al., 1964; Oehm, 1972). Zirconium is also toxic in like amounts in small mammals (Kang et al., 1977) and is potentially carcinogenic in small mammals (Turk and Parker, 1977) and has been noted as toxic to the human fetus (Scanlon, 1975).

Therefore, the easy and rapid detection of toxic levels of these metals in a water source known to be polluted by one or another of them or a quantitative indication of pollution at a toxic level, of unknown origin and of whatever nature, is a necessary tool in the evaluation of the safety of water for animal and human consumption.

Our previous studies by these methods of measurement show that they are effective and accurate to determine toxic and subtoxic levels of other metals (Ag, Cd, Fe, Ni, Pb, Cu; Bovee et al., 1977), providing an effective bioassay. These studies on Se, Va and Zr also indicate its utility.

Further, it is not necessary to use the detailed photographic procedures. Visual observation is sufficient. If the organisms have stopped, or nearly stopped swimming in 30 to 40 min in the water being tested, there is a significant level of pollutant(s) in the water. Although the present method will not identify the pollutant (unless it is already known) nor indicate the quantity of it present in the water, it can serve as a means of assessing the relative safety of a water source and can determine the presence of potentially dangerous pollutants that should be quantitatively assessed by more critical methods.

Literature Cited

Bergquist, B. L. 1974. The effects of cadmium upon growth, locomotion and ultrastructure of *Tetrahymena pyriformis*. PhD. Dissertation. Univ. Kansas, Lawrence. 147 p.

Bergquist, B. L. and E. C. Bovee. 1976. Cadmium: quantitative methodology and study of its effect upon the locomotor rate of *Tetrahymena pyriformis*. Acta Protozool. 15:471-483.

BICK, H. 1973. Population dynamics of Protozoa associated with the decay of organic matter in fresh water. Amer. Zool. 13:149-160.

BOVEE, E. C. 1965. An ecological study of amoebas from a small stream in northern Florida. Hydrobiologia 25:69-87.

BOVEE, E. C., B. L. BERGQUIST, E. WYTTENBACH, D. J. STERNSHEIN and A. TIPPITT. 1977. Effects of heavy metals on *Teterahymena pyriformis:* a summary. Abst., 5th Intern. Congress Protozool., New York, June 1977. p. 318.

BOVEE, E. C., D. A. KEGLEY, D. STERNSHEIN, E. WYTTENBACH and B. L. BERGQUIST. 1979. Alleviation of the toxicity of copper to *Tetrahymena pyriformis* by nontoxic iron. Kansas Sci. Bull. 51:679-684.

BURBANCK, U. D. and D. M. SPOON. 1967. Use of sessile ciliates collected in petri dishes for rapid assessment of water pollution. J. Protozool. 4:739-744.

CAIRNS, J., JR. 1973. Factors affecting the numbers of species in freshwater Protozoan communities, pp. 219-247. *In* J. Cairns (ed.), The Structure and Function of Fresh-Water Microbial Communities. Res. Div. Monogr. #3. Va. Polytech. Inst. State Univ., Blacksburg, Va.

CARTER, J. W. and I. L. CAMERON. 1973. Toxicity assay of heavy metals in water, using *Tetrahymena pyriformis*. Water Res. 7:951-961.

CHALKLEY, H. W. 1930. Stock cultures of *Amoeba proteus*. Science 71:442.

COOLEY, N. R., J. M. KELTNER, JR. and J. FORESTER. 1972. Mirex and Achlor 1254: effect on and accumulation by *Tetrahymena pyriformis*. J. Protozool. 19:636-639.

CUNJA, T. J. 1973. The value of selenium in animal feeding. Feedstuffs 45:21-27.

HATHCOCK, J. N., C. HILL and G. MATRONE. 1964. Vanadium toxicity and distribution in chicks and rats. J. Nutrition 82:106-111.

KANG, K. Y., D. BICE, E. HOFFMAN, R. D'AMATO and J. SALVAGGIO. 1977. Experimental studies of sensitization to beryllium, zirconium and aluminum compounds in the rabbit. J. Allergy Clin. Immunol. 59:425-436.

LACKEY, J. B. 1938. Protozoan plankton as indicators of pollution in a flowing stream. Publ. Health Repts. 53:2037-2042.

———. 1968. The Ecology of *Euglena*, p. 28-44. *In* D. Buetow (ed.), The Biology of Euglena, Vol. I. Academic Press, N.Y.

MAKINDE, C. A. 1979. The toxic effect of vanadyl sulfate upon the growth of *Tetrahymena pyriformis*. M.A. Thesis. Univ. of Kansas, Lawrence. 85 p.

MILLS, W. L. 1973. Some toxicity studies on selected Protozoa in certain toxicities of mercury. PhD. Dissertation. Univ. of Kansas, Lawrence. 128 p.

MUHLER, J. C. 1957. The effects of vanadium pentoxide, fluoride and tin compounds on the dental experience of rats. J. Dental Res. 36:787-794.

NIIMI, A. J. and Q. N. LAHAM. 1976. Relative toxicity of organic and inorganic compounds of selenium to newly-hatched zebra fish. Can. J. Zool. 54:501-509.

OEHM, F. W. 1972. The mechanism of heavy metal toxicities. Clin. Toxicol. 151-167.

RUTHVEN, J. A. and J. CAIRNS, JR. 1973. Response of Protozoan freshwater artificial communities to metals. J. Protozool. 20:127-129.

SCANLON, J. W. 1975. Dangers to the human fetus from certain heavy metals in the environment. Rev. Environ. Health 2:39-64.

SCHREIBER, D. E. 1978. The effects of vanadium upon the growth of *Tetrahymena pyriformis*. M.A. Thesis. Univ. of Kansas, Lawrence. 85 p.

SMALL, E. B. 1973. A study of ciliate protozoa from a small polluted stream in east central Illinois. Amer. Zool. 13:225-230.

SOKOL, R. R. and F. J. ROHLF. 1969. Biometry. Freeman, San Francisco.

SUNDARESEN, B. B., E. C. BOVEE, D. E. WILSON and J. B. LACKEY. 1965. Effects of wood reduction waste pollution on the microbial ecology of a small creek. J. Water Poll. Contr. Fed. 37:1536-1544.

TIPPITT, A. D. 1975. The effects of selenium upon the growth and locomotion of *Tetrahymena pyriformis*. M.A. Thesis. Univ. of Kansas, Lawrence. 110 p.

TURK, J. L. and D. PARKER. 1977. Granuloma formation in normal guinea pigs injected intradermally with aluminum and zirconium compounds. J. Invest. Dermatol. 68:336-340.

WEAST, R. C. 1970. Handbook of Chemistry and Physics, 51st ed., p. B-36. Chemical Rubber Co., Cleveland.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

MUS. COMP. ZOOL
LIBRARY
FEB 10 1983
HARVARD
UNIVERSITY

ETHOMETRICS OF FIVE SYMPATRIC COCKROACH SPECIES IN NORTHEASTERN KANSAS

By
Robert E. Gorton, Jr.
and
W. J. Bell

Vol. 52, No. 5, pp. 45-58 January 21, 1983

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 5, pp. 45-58 January 21, 1983

Ethometrics of Five Sympatric Cockroach Species in Northeastern Kansas

Robert E. Gorton, Jr.[1] and W. J. Bell
Department of Entomology, University of Kansas, Lawrence, Kansas 66045

Contents

Abstract 45
Introduction 45
Materials and Methods 46
Animal maintenance and observational procedures 46
Definition of acts 46
Analysis of encounters as units 47
Informational analysis 47
Diads 50
Results 50
Comparison of the behavioral repertoires 50
Parameters of agonistic behavior 50
Informational analyses 52
Diad analysis 55
Discussion 55
Acts and encounters 55
Informational analyses 57
Acknowledgments 58
Literature Cited 58

Abstract

Five species of cockroaches in the genera *Parcoblatta* and *Ischnoptera* were collected in the field and observed under laboratory conditions. The behavioral repertoires of each species were determined, analyzed, and compared. Frequencies and sequences of acts, agonistic intensity, and lengths of encounters were considered. Informational analyses were employed to determine the constraints the acts of one organism placed on the following acts of another and to determine the amount of information transmitted from one animal to another. Ecological and evolutionary implications of the results were discussed.

Introduction

Agonistic behavior is a common way for organisms to affect access to and control of resources. Such behavior signals the willingness or unwillingness of individuals to defend, usurp, or share those resources with other individuals. In general, agonistic behavior is the mechanism by which organisms effect their social environments.

Using certain techniques, especially Markovian analyses, it is possible to quan-

[1] Present address: Division of Biology, Kansas State University, Manhattan, Kansas 66506.

tify and predict acts, sequences of acts, and the dependence of the behavior of one animal on the behavior of another (Steinberg and Conant, 1974; Steinberg, 1977; Bell et al., 1979). With these techniques in mind, a comparative study was undertaken of five species of sympatric cockroaches to determine, define, and compare the behavioral repertoires, frequencies and sequences of acts, the intensity and duration of agonistic encounters, and the interdependence of acts and runs of acts for conspecific encounters in *Parcoblatta pennsylvanica, P. lata, P. virginica, P. uhleriana,* and *Ischnoptera deropeltiformis.* From these data the adaptive significances of the patterns derived are suggested.

MATERIALS AND METHODS

Animal Maintenance and Observational Procedures

Six field-captured animals were placed in each of three clear plastic cages 30×19×12.5 cm, covered by see-through plastic tops and placed on a 12:12 h photocycle at 26° C and 40% RH. After 24 h the animals were observed at various times during the dark period of the photocycle under red light (invisible to the cockroaches; Walther and Dodt, 1957) until a minimum of 250 encounters had been observed and recorded on cassette tape for later transcription. When an individual died it was replaced and observations were continued after waiting another 24 h. Food and water were supplied ad lib.

Definition of Acts

The acts comprising the behavioral repertoires utilized in encounters with conspecific members of the same sex by *I. deropeltiformis* and *Parcoblatta* spp. were defined as follows:

Approach (A): moving toward and contacting another individual. This act began all encounters by definition.

Antennate (AN): contacting an individual with the antennae, without the act being coupled with "approach" above.

Bite (B): grasping another individual with the mandibles; a dangerous act sometimes resulting in lost body parts.

Kick (K): kicking an animal, usually with the hind leg, occasionally with the middle leg.

Stilt (S): raising the body off the substrate by extension of the legs and often pointing the tip of the abdomen vertically. Considered a warning or threat posture.

Stilt-kick (S-K): kicking is executed as the body is lifted off the substrate (a composite act of the two acts above).

Climb (C): non-sexual mounting and walking on the back of another individual.

Jerk (J): rapidly vibrating the body one or more times in an anterioposterior direction without locomotion.

Lunge (L): rapidly moving toward another individual.

Does nothing (DN): remaining motionless, without changing from normal posture; the absence of an observable response.

Retreat (R): rapidly moving away from an individual (running); usually a terminating act.

Fly (F): taking flight (a terminal act).

Withdraw (W): slowly moving away from another individual (walking); usually a terminal act.

Truce (T): remaining in contact with another individual with no further interaction for at least 5 sec (a terminal act).

Back (BA): backing toward an ap-

proaching animal (only in *I. deropeltiformis*).

Butt (BU): ramming another individual with the pronotum (only in *I. deropeltiformis*).

Lean (LE): tilting the dorsum sidewise in the direction of an approaching individual by flexing the legs on one side and extending the legs on the other (only in *P. pennsylvanica*).

The frequencies and probabilities of acts as a function of whether they were performed by the initiator of an encounter (that animal performing the first act of an encounter) or the responder (that animal performing the second act of an encounter) were calculated (Table 1).

Analyses of Encounters as Units

Agonistic intensity of each encounter was determined using an ordinal scale of one to five, depending on the intensity of the acts comprising the encounter (Table 2). The frequencies of the numbers of encounters falling into each agonistic level and the overall mean for each species is given in Table 3. Statistical significance of the differences in mean levels of agonistic intensity of encounters between males and females of the same species was determined using the Smirnov 2-sample test (Table 4). Statistical significance of differences in the frequency distributions of agonistic levels (Table 3) of males of a species with males of each other species and females of a species with females of each other species was determined using the 2×2 contingency test (Table 5). Means and ranges of encounter lengths in numbers of acts were calculated (Table 6) and compared with ANOVA and SNK tests.

Informational analyses

Information theory provides a means of dissecting the dependence of one animal's acts on another through the course of an interaction. It provides a mechanism by which one can investigate the probabilistic constraints placed on the behavior of one animal by the acts of another, the restrictive value carried by specific acts, and the importance of an animal's preceding acts in determining its own subsequent behavior (Steinberg, 1977).

The measure of the diversity of acts chosen by the responder as influenced by the initiator is $H(x)$, such that

$$H(x) = -\Sigma P_{(j/i)} \log_2 P_{(j/i)}$$

where $P_{(j/i)}$ is the probability of the jth act executed by the responder given the ith act by the initiator has just occurred, and similarly for the diversity of the acts chosen by the initiator as influenced by the responder. When this index is normalized for the number of acts in the repertoire of a species, it provides a means of interspecific comparison. Normalized diversity varies from zero (complete certainty about the response to a given act) to one (complete uncertainty about the act that will follow the act in question, i.e., statistical independence) (Tables 7 and 8).

Transmission, $T(X;Y)$, is a measure of the information transferred. It is a measure of relatedness, equaling zero if the acts of the two animals are statistically independent:

$$T(X;Y) = H(Y) - H(Y/X).$$

This index is derived from the Shannon-Wiener index of diversity:

$$H(Y) = -\Sigma P_i \log_2 P_i$$

where Y symbolizes the categories of acts and P_i is the probability of the ith value of Y, and from the conditional uncertainty index:

$$H(Y/X) = -\Sigma P_{ij} \log_2 P_{(j/i)}$$

and similarly for $H(X)$ and $H(X/Y)$. The value by which $T(X;Y)$ approaches

TABLE 1. Frequencies and probabilities of acts in the behavioral repertoires of each species. Animal A is the initiator of the encounter, Animal B the responder. (See Materials and Methods for explanation of symbols.)

	I. deropeltiformis				*P. virginica*			
	Males	(N=924)	Females	(N=923)	Males	(N=965)	Females	(N=1039)
	A	B	A	B	A	B	A	B
A	262	1	272	1	281	7	274	9
	(.2835)	(.0011)	(.2947)	(.0011)	(.2912)	(.0073)	(.2637)	(.0087)
AN	44	21	37	23	52	61	69	63
	(.0476)	(.0227)	(.0401)	(.0249)	(.0539)	(.0632)	(.0664)	(.0606)
DN	6	17	2	35	9	52	7	39
	(.0065)	(.0184)	(.0022)	(.0379)	(.0093)	(.0539)	(.0067)	(.0375)
B	—[1]	—	0	2	22	23	49	28
			(.0000)	(.0022)	(.0228)	(.0238)	(.0472)	(.0269)
S-K	4	86	0	39	—	—	—	—
	(.0043)	(.0931)	(.0000)	(.0422)				
R	4	3	20	34	32	80	52	83
	(.0043)	(.0032)	(.0217)	(.0368)	(.0332)	(.0829)	(.0500)	(.0799)
C	11	0	45	3	14	1	14	4
	(.0119)	(.0000)	(.0487)	(.0033)	(.0145)	(.0010)	(.0135)	(.0038)
J	2	31	1	30	1	10	0	22
	(.0022)	(.0335)	(.0011)	(.0325)	(.0010)	(.0104)	(.0000)	(.0212)
L	2	5	6	12	17	26	22	40
	(.0022)	(.0054)	(.0065)	(.0130)	(.0176)	(.0269)	(.0212)	(.0385)
S	9	57	5	78	1	37	1	35
	(.0097)	(.0617)	(.0054)	(.0845)	(.0010)	(.0383)	(.0009)	(.0337)
W	133	7	111	33	91	41	64	30
	(.1439)	(.0076)	(.1203)	(.0357)	(.0943)	(.0425)	(.0616)	(.0289)
T	90	12	44	12	19	13	25	19
	(.0974)	(.0130)	(.0477)	(.0130)	(.0197)	(.0135)	(.0241)	(.0183)
K	7	108	3	69	13	61	11	79
	(.0076)	(.1169)	(.0033)	(.0747)	(.0135)	(.0632)	(.0106)	(.0760)
F	†††[2]	†††	—	—	0	1	—	—
					(.0000)	(.0010)		
BA	2	0	—	—	—	—	—	—
	(.0022)	(.0000)						
BU	—	—	5	1	—	—	—	—
			(.0054)	(.0011)				

	P. pennsylvanica				*P. uhleriana*			
	Males	(N=907)	Females	(N=1049)	Males	(N=869)	Females	(N=863)
	A	B	A	B	A	B	A	B
A	282	0	276	6	262	1	268	4
	(.3109)	(.0000)	(.2631)	(.0057)	(.3015)	(.0011)	(.3105)	(.0046)
AN	44	51	47	29	31	60	31	41
	(.0485)	(.0562)	(.0448)	(.0276)	(.0357)	(.0690)	(.0359)	(.0475)
DN	2	65	4	15	1	28	2	16
	(.0022)	(.0717)	(.0038)	(.0143)	(.0011)	(.0322)	(.0023)	(.0185)
B	2	0	51	36	10	10	9	4
	(.0022)	(.0000)	(.0486)	(.0343)	(.0115)	(.0115)	(.0104)	(.0046)
S-K	0	3	3	22	1	11	2	21
	(.0000)	(.0033)	(.0028)	(.0209)	(.0011)	(.0126)	(.0023)	(.0243)
R	11	81	33	47	42	81	43	69
	(.0121)	(.0893)	(.0315)	(.0448)	(.0483)	(.0932)	(.0498)	(.0799)
C	44	5	20	7	22	3	9	6
	(.0485)	(.0055)	(.0191)	(.0067)	(.0253)	(.0034)	(.0104)	(.0069)
J	2	14	0	16	1	15	0	13
	(.0022)	(.0154)	(.0000)	(.0153)	(.0011)	(.0173)	(.0000)	(.0151)

TABLE 1. (concluded)

	P. pennsylvanica				*P. uhleriana*			
	Males	(N=907)	Females	(N=1049)	Males	(N=869)	Females	(N=863)
	A	B	A	B	A	B	A	B
L	4	3	14	9	26	29	21	38
	(.0044)	(.0033)	(.0133)	(.0086)	(.0299)	(.0334)	(.0243)	(.0440)
S	3	54	12	129	3	50	7	78
	(.0033)	(.0595)	(.0114)	(.1229)	(.0034)	(.0575)	(.0081)	(.0904)
W	104	55	98	30	97	30	80	27
	(.1147)	(.0606)	(.0934)	(.0286)	(.1116)	(.0345)	(.0927)	(.0313)
T	14	3	39	9	7	3	38	3
	(.0154)	(.0033)	(.0372)	(.0086)	(.0081)	(.0034)	(.0440)	(.0035)
K	0	53	12	87	1	42	2	31
	(.0000)	(.0584)	(.0114)	(.0829)	(.0011)	(.0483)	(.0023)	(.0359)
F	0	1	—	—	2	0	—	—
	(.0000)	(.0011)			(.0023)	(.0000)		
LE	0	3	—	—	—	—	—	—
	(.0000)	(.0033)						

	P. lata			
	Males	(N=807)	Females	(N=879)
	A	B	A	B
A	269	3	277	4
	(.3333)	(.0037)	(.3153)	(.0046)
AN	38	42	36	74
	(.0471)	(.0520)	(.0409)	(.0842)
DN	1	20	0	18
	(.0012)	(.0248)	(.0000)	(.0205)
B	1	0	3	2
	(.0012)	(.0000)	(.0034)	(.0023)
S-K	0	11	0	17
	(.0000)	(.0136)	(.0000)	(.0193)
R	30	122	29	103
	(.0372)	(.1512)	(.0329)	(.1172)
C	6	1	17	0
	(.0074)	(.0012)	(.0193)	(.0000)
J	0	8	0	9
	(.0000)	(.0099)	(.0000)	(.0102)
L	23	13	30	19
	(.0285)	(.0161)	(.0341)	(.0216)
S	3	62	4	65
	(.0037)	(.0768)	(.0046)	(.0739)
W	84	15	97	28
	(.1041)	(.0186)	(.1103)	(.0318)
T	7	1	11	2
	(.0087)	(.0012)	(.0125)	(.0023)
K	2	44	4	30
	(.0025)	(.0545)	(.0046)	(.0341)
F	0	1	—	—
	(.0000)	(.0012)		

[1] Not part of behavioral repertoire.
[2] Part of behavioral repertoire, but not observed in experiments.

$H(Y)$ is a measure of the influence of the act of the initiator on the act of the responder, and similarly for $T(Y;X)$ and $H(X)$. Transmission can be normalized to decrease the influence of the number of behavioral categories chosen by a par-

ticular investigator for a given system in the following manner:

$$t(X;Y) = \frac{T(X;Y)}{H(Y)}$$

allowing cross-species comparisons (Table 9). Variances of transmission indices were calculated as described in Steinberg (1977):

$$\text{Var } T(X;Y) = (\Sigma\Sigma(P_{ij}(\log_2(P_{ij}/P_iP_j)^2) - T(X;Y))/N.$$

Diads

The most common 2-act sequences for each species were determined and diagrammed in Figure 1. From these diads, it was possible to contrast and compare typical encounters.

RESULTS

Comparison of the Behavioral Repertoires

The behavioral repertoires of the *Parcoblatta* spp. and *Ischnoptera* were virtually identical in the acts employed (Table 1), with the following exceptions: "back" was unique to *I. deropeltiformis* males, while "butt" was unique to females of this species. "Lean" was unique to *P. pennsylvanica* males. "Stilt-kick" was never observed in either sex of *P. virginica,* and "bite" was never observed in *Ischnoptera* males.

There was variation in the relative proportions of the acts observed within and between species, e.g., "retreat" was rare in *Ischnoptera* males, but comparatively common in females of that species, and "stilt" was proportionately nearly four times as common in *P. virginica* females as in *P. pennsylvanica* females. *Ischnoptera* and *P. pennsylvanica* were often on one extreme or other in relative proportions of acts chosen, e.g., "stilt-kick" was common in *Ischnoptera* but uncommon in the *Parcoblatta* species, while "lunge" was least common in the two aforementioned species. An interesting finding in all species was that 46-50% of the total numbers of acts in the repertoires comprised 77.5% (*P. pennsylvanica* females) to 92.9% (*P. lata* males) of all acts used in intraspecific encounters.

Some acts were characteristic of the initiator of an encounter, determined by that animal perpetrating at least 66.7% of the frequency of a given act: "approach" and "climb." Other acts, "jerk," "stilt," and "does nothing," were characteristic of the responder. "Truce" was characteristic of the initiator in four of the five species studied, while "kick" and "stilt-kick" were acts chosen by the responder in four of the five species studied. The remaining acts showed variability within and between sexes and species (Table 1).

TABLE 2. Levels of agonistic behavior.

Level
1: encounters in which the major elements are antennation, retreat, withdraw, or truce.
2: encounters in which the major elements are threat or intention movements (stilt, jerk, climb, lunge).
3: encounters in which the major elements are biting or kicking, demonstrated by one animal.
4: encounters in which the major elements are biting and/or kicking, demonstrated by both animals.
5: encounters in which the major elements are biting and/or kicking while both animals turn in a tight circle while engaging in these behaviors.

Parameters of Agonistic Behavior

When the frequencies of encounters falling into the five levels of agonism (Table 2) were determined (Table 3), the following patterns emerged: males and females had different mean levels of agonism in three of the five species (*P. pennsylvanica, P. virginica,* and *I. deropeltiformis*) (Table 4). When *Parcoblatta* females overall were compared with *Parcoblatta* males, there was a strong trend for females to be more intensely agonistic than males (sign test; $P < .06$). Males of *Ischnoptera* were significantly more agonistic than any of the *Parcoblatta* males

TABLE 3. Frequencies of the levels of agonism in male-male and female-female interactions.

	P. lata				*P. uhleriana*			
Level	Males	(*N*=250)	Females	(*N*=250)	Males	(*N*=250)	Females	(*N*=250)
1	110	(44.00%)	99	(39.60%)	91	(36.40%)	78	(31.20%)
2	92	(36.80%)	109	(43.60%)	104	(41.60%)	120	(48.00%)
3	47	(18.80%)	38	(15.20%)	51	(20.40%)	48	(19.20%)
4	1	(0.40%)	4	(1.60%)	3	(1.20%)	3	(1.20%)
5	0		0		1	(0.40%)	1	(0.40%)
$\bar{X}$ =	1.756		1.788		1.876		1.916	
	P. virginica				*P. Pennsylvanica*			
Level	Males	(*N*=263)	Females	(*N*=256)	Males	(*N*=250)	Females	(*N*=250)
1	114	(43.35%)	72	(28.12%)	101	(40.40%)	32	(12.80%)
2	85	(32.32%)	105	(41.02%)	100	(40.00%)	107	(42.80%)
3	53	(20.15%)	56	(21.87%)	47	(18.80%)	81	(32.40%)
4	5	(1.99%)	16	(6.25%)	2	(0.80%)	26	(10.40%)
5	6	(2.28%)	7	(2.74%)	0		4	(1.60%)
$\bar{X}$ =	1.874		2.144		1.800		2.452	
	I. deropeltiformis							
Level	Males	(*N*=250)	Females	(*N*=250)				
1	12	(4.80%)	37	(14.80%)				
2	84	(33.60%)	115	(46.00%)				
3	150	(60.00%)	96	(38.40%)				
4	4	(1.60%)	2	(0.80%)				
5	0		0					
$\bar{X}$ =	2.584		2.252					

(Table 5). Females were significantly different in agonistic intensity from each other with two exceptions: *P. uhleriana* and *P. lata* were statistically identical, as were *P. pennsylvanica* and *I. deropeltiformis* (Table 5).

Males and females showed significant intrasexual differences in the mean numbers of acts comprising an encounter, defined as the sum of the acts employed by both of the individuals involved. *Parcoblatta lata* males had significantly shorter encounters than all species except *P. uhleriana* (ANOVA, $P < .001$; SNK, $P < .05$) (Table 6). This difference was the only significant difference observed in males regarding encounter length. Likewise, *P. lata* females had, on the average, fewer acts per encounter than all other females (Table 6). *Parcoblatta uhleriana* and *I. deropeltiformis* females had significantly fewer acts per encounter than *P. pennsylvanica* and *P. virginica* females, and more than *P. lata* females. *Parcoblatta virginica* and *P. pennsylvanica* females had significantly higher mean encounter lengths than all other species, but were not significantly different from each other. Ranges were

TABLE 4. Analysis of differences in agonistic levels comparing males and females (Smirnov 2-sample test). ($T = \max |S_1(x) - S_2(x)|$, where $S_1(x)$ and $S_2(x)$ are empirical distribution functions of the random samples.)

Species	*T*	α-level
P. pennsylvanica	0.276	0.01
P. virginica	0.152	0.01
P. uhleriana	0.052	n.s.[1]
P. lata	0.044	n.s.
I. deropeltiformis	0.224	0.01

[1] Not significant.

TABLE 5. Comparison of the frequencies of agonistic levels in *Parcoblatta* and *Ischnoptera*. Numbers in the matrix indicate *T*-values of pairwise 2×2 contingency tests (Class 1: agonism scores of 1-2; Class 2: agonism scores of 3-5. See Table 2 for definition of agonistic levels). Values for males are given above the diagonal, values for females, below.

	I. deropeltiformis	*P. pennsylvanica*	*P. uhleriana*	*P. lata*	*P. virginica*
P. virginica	72.8[2]	1.8[1]	0.4[1]	2.3[1]	—
P. lata	93.3[2]	0.01[1]	0.6[1]	—	13.7[2]
P. uhleriana	80.6[2]	0.4[1]	—	2.6[1]	6.7[5]
P. pennsylvanica	46.9[2]	—	31.7[2]	44.8[2]	9.9[4]
I. deropeltiformis	—	1.4[1]	20.8[2]	31.1[2]	3.7[3]

[1] not significant; [2] $P < .001$; [3] $P < .05$; [4] $P < .005$; [5] $P < .015$.

TABLE 6. Analysis of mean encounter lengths in numbers of acts in *Parcoblatta* and *Ischnoptera*. Underlines indicate lack of significant differences (ANOVA and SNK test; $P < .05$). Numbers above species names indicate mean numbers of acts per encounter and numbers below indicate ranges of encounter lengths.

Males

3.68	3.67	3.63	3.47	3.23
P. virginica	*I. deropeltiformis*	*P. pennsylvanica*	*P. uhleriana*	*P. lata*
(2-12)	(2-8)	(2-7)	(2-9)	(2-11)

Females

4.20	4.00	3.70	3.45	3.12
P. pennsylvanica	*P. virginica*	*I. deropeltiformis*	*P. uhleriana*	*P. lata*
(2-18)	(2-13)	(2-13)	(2-8)	(2-9)

TABLE 7. Normalized diversity of acts in males of *Parcoblatta* and *Ischnoptera*.

	P. uhleriana		*P. lata*		*P. pennsylvanica*		*P. virginica*		*I. deropeltiformis*	
Act	A to B	B to A	A to B	B to A	A to B	B to A	A to B	B to A	A to B	B to A
A	.90	xxx[1]	.80	xxx	.81	xxx	.86	xxx	.80	xxx
AN	.81	.66	.77	.88	.90	.66	.86	.79	.48	.88
DN	xxx	.83	xxx	.82	xxx	.70	xxx	.83	xxx	.84
S	xxx	.78	xxx	.78	xxx	.72	xxx	.64	xxx	.68
S-K	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	.69
J	xxx	.82	xxx	xxx	xxx	.94	xxx	xxx	xxx	.72
K	xxx	.79	xxx	.71	xxx	.85	.94	.81	xxx	.70
B	xxx	xxx	xxx	xxx	xxx	xxx	.80	.87	xxx	xxx
C	.81	xxx	xxx	xxx	.82	xxx	.81	xxx	xxx	xxx
L	.30	.32	.43	.49	xxx	xxx	.48	.73	xxx	xxx

[1] Occurring with a frequency of less than 12.

similar in all species except *P. pennsylvanica* females, in which an encounter could consist of up to 18 discrete acts.

Informational Analyses

The diversity of acts resulting from the perpetration of a given act (Tables 7 and 8) differed on that act and on which animal, the initiator (A) or the responder (B) perpetrated it. The effect of the acts of the initiators on the following acts of the responders showed that "approach"

had the least constraining effect on the following acts in four of the five species in both sexes (*P. uhleriana, P. lata, P. virginica,* and *I. deropeltiformis*), while "antennate" had comparatively little effect in at least one sex of all of the species studied (*P. uhleriana, P. lata, P. virginica, I. deropeltiformis* females, and *P. pennsylvanica* males). Conversely, "lunge" was the most determining act in three of the five species studied in both sexes (*P. uhleriana, P. lata,* and *P. virginica*). "Climb" was second only to "lunge" in determining power in females of two species (*P. lata* and *P. virginica*), and showed the highest degree of determining power in females of *I. deropeltiformis.* The effect of the responders on the following acts of the initiators was least for "does nothing" in at least one sex of all five species (*P. uhleriana, P. lata, P. virginica, P. pennsylvanica* females, and *I. deropeltiformis* males). "Lunge" was again a highly determining act in at least one sex in four species (*P. lata, P. uhleriana, P. virginica,* and *I. deropeltiformis* females). "Stilt," "kick," or "stilt-kick" were of little determining effect in males of *P. pennsylvanica* and in all females, but rather high in *I. deropeltiformis* and in males of *P. virginica.* "Antennate" was among the least determining acts in males of *P. lata* and in *I. deropeltiformis,* but among the most determining acts in *P. uhleriana, P. pennsylvanica,* and in females of *P. lata.* "Jerk" and "bite" were rather non-determining acts in males of *P. uhleriana, P. pennsylvanica,* and *P. virginica* and in *I. deropeltiformis* females,

TABLE 8. Normalized diversity of acts in females of *Parcoblatta* and *Ischnoptera.*

	P. uhleriana		*P. lata*		*P. pennsylvanica*		*P. virginica*		*I. deropeltiformis*	
Act	A to B	B to A	A to B	B to A	A to B	B to A	A to B	B to A	A to B	B to A
A	.85	xxx[1]	.88	xxx	.75	xxx	.91	xxx	.89	xxx
AN	.91	.71	.93	.72	.74	.76	.86	.85	.84	.75
DN	xxx	.92	xxx	.96	xxx	.91	xxx	.92	xxx	.69
S	xxx	.79	xxx	.81	.87	.89	xxx	.79	xxx	.77
S-K	xxx	.81	xxx	.86	xxx	.88	xxx	xxx	xxx	.82
J	xxx	.73	xxx	xxx	xxx	.86	xxx	.85	xxx	.89
K	xxx	.81	xxx	.75	xxx	.84	xxx	.86	xxx	.80
B	xxx	xxx	xxx	xxx	.80	.76	.85	.78	xxx	xxx
C	xxx	xxx	.52	xxx	.85	xxx	.81	xxx	.77	xxx
L	.45	.35	.00	.00	.83	xxx	.52	.54	xxx	.71

[1] Occurring with a frequency of less than 12.

TABLE 9. Information transferred (bits) in encounters of *Parcoblatta* and *Ischnoptera,* ± 2 SD. Normalized transmission (see text) is given in parentheses for each category.

Species	Male: A to B	Male: B to A	Female: A to B	Female: B to A
P. uhleriana	0.45±.04 (0.14)	0.83±.02 (0.30)	0.43±.04 (0.14)	0.86±.03 (0.30)
P. lata	0.29±.04 (0.11)	0.69±.03 (0.27)	0.42±.04 (0.15)	0.75±.03 (0.28)
P. pennsylvanica	0.20±.04 (0.07)	0.56±.05 (0.23)	0.58±.03 (0.19)	0.49±.03 (0.16)
P. virginica	0.49±.04 (0.16)	0.77±.02 (0.27)	0.43±.04 (0.14)	0.83±.03 (0.28)
I. deropeltiformis	0.46±.05 (0.18)	0.30±.04 (0.13)	0.37±.04 (0.12)	0.47±.04 (0.18)

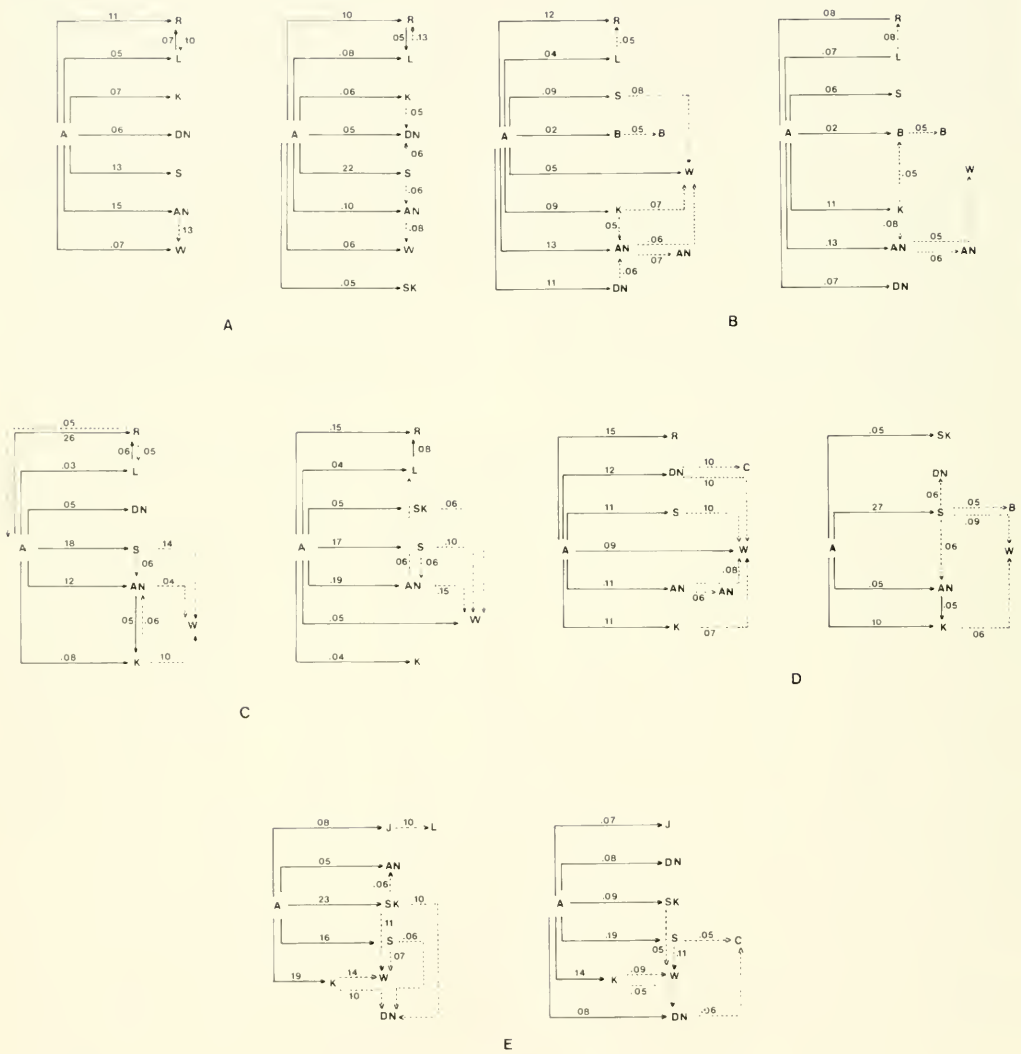


FIG. 1. Diagrams of common diads in *Parcoblatta* and *Ischnoptera*. A: *P. uhleriana*. B: *P. virginica*. C: *P. lata*. D: *P. pennsylvanica*. E: *I. deropeltiformis*. Right-hand diagrams are of females, left-handed diagrams are of males.

but were rather of high determining value in females of *P. pennsylvanica* and *P. virginica*.

Table 9 displays the amount of information transferred in conspecific encounters. In each of the *Parcoblatta* species (except *P. pennsylvanica* females) more information was transferred by the responder to the initiator than vice versa, by roughly twice in most cases. Males and females of *Parcoblatta* showed similar amounts of information transferred, again with the exception of *P. pennsylvanica*. *Ischnoptera* males showed more information transferred to the responder than to the initiator, while females of that species followed the pattern of *Parcoblatta*. The difference in information transferred by responders and initiators was less pronounced in *Ischnoptera* than in *Parcoblatta*, with the *P. pennsylvanica* exception.

Diad Analysis

The most common diads in the A to B direction in both sexes were very similar: A-AN, A-R, and/or A-S were the three most common sequences in *P. uhleriana* and *P. lata* and comprised two of the three most common sequences in *P. virginica* and *P. pennsylvanica* (Fig. 1). Indeed, A-S was in the top three most common diads in every species but *P. virginica*, A-AN in every species but *I. deropeltiformis*, and A-R in *P. uhleriana*, *P. virginica*, *P. lata*, and males of *P. pennsylvanica*. "Approach-Kick" and/or A-(S-K) figured in the three most common sequences in *P. virginica* females and were two of those three in *I. deropeltiformis* and in *P. pennsylvanica* females.

In the B to A direction, S-W was among the top two most common diads in *P. lata*, *P. pennsylvanica*, *P. virginica* males, and *I. deropeltiformis* females, while K-W and/or (S-K)-W were in the top two diads in *I. deropeltiformis*, males of *P. virginica* and *P. lata*, and females of *P. pennsylvanica* (Fig. 1).

Typical encounters involved the sequence A-S-W in *P. lata* males and females of *P. pennsylvanica* and *I. deropeltiformis*, and either A-AN-W, A-DN-W, or A-AN-AN in *P. virginica*, males of *P. uhleriana* and *P. pennsylvanica*, and females of *P. lata*.

Discussion

Acts and Encounters

The species studied had virtually identical behavioral repertoires, differing in relatively rare acts (Table 1). This is due, at least in part, to phylogenetic history: the species are very closely related. It is also probably due to the fact that the species are all sympatric and encounter and compete with one another (Gorton, 1980). Selection may have operated to minimize divergence in the communication systems, allowing for efficient interspecific as well as intraspecific communication. Indeed, the primary source of variation was not in the behavioral repertoires but in the relative frequencies with which individual acts were chosen. *Parcoblatta pennsylvanica* and *I. deropeltiformis* commonly represented the extremes in the frequencies of acts: *Ischnoptera*, the only non-congener in the study, was the most phylogenetically divergent of the species, thereby having more time for differences to accumulate. *Parcoblatta pennsylvanica* occurs at significantly greater heights than the other species (Gorton, 1980), making it the most isolated of the *Parcoblatta* community. This isolation may have led to a less generalized behavior pattern. It should be noted that *I. deropeltiformis* and *P. pennsylvanica* are also the most morphologically divergent of the species studied, suggesting that the remaining species are more closely related to each other. This fact may have behavioral implications. Furthermore, the

other *Parcoblatta* species probably encounter each other rather frequently and therefore are the most similar in choice and frequencies of acts.

Within a species, initiators chose relatively nonaggressive acts, whereas responders chose warning and threat postures and potentially damaging acts. It is likely that the initial approach is an information gathering behavior, used to determine sex, health (damaged insects are commonly eaten), motivational state, and degree of relatedness (Gorton, 1979). A responder must signal its ability to defend itself or leave the area. Failure to do so may encourage attack and possible damage.

Encounters tended to be of short duration and to consist of small numbers of acts. Thus, assessment is quickly made and the winner of an agonistic encounter quickly determined. In species lacking dominance heirarchies or a system of site specificity (see Bell and Gorton, 1978; Gorton et al., 1979), short-lived encounters are probably adaptive in that decisions regarding responses are made before serious damage may occur.

To select for agonism, resources must be defendable, energetically expedient to defend, and limiting (Brown, 1964). Apparently, resources required by females have these characteristics. Females of four of the species considered had higher mean levels of agonism than males, with the difference being statistically significant in three of them. This difference in agonistic intensity suggests that females are under greater selective pressure in this parameter than males. Since oothecae are produced and transported by Blattellid females and since oothecae may be cannibalized (Gorton, 1979), females probably require more energy per unit time and spend more of their time actively foraging and searching for good oothecal deposition sites (McKittrick, 1964), as well as fighting to maintain as much distance between themselves and other females as possible. The potential reduction in fitness incurred through cannibalism and their greater energy requirements may well manifest themselves behaviorally in high levels of agonism. Females are very active in the field, while males tend to be stationary. Therefore encounter rates are probably much higher between females. Since males are capable of flight, they can disperse comparatively far, minimizing the probability of repeated encounters. Males have short life spans, significantly smaller bodies, and lower locomotory rates, and, considering the energy requirements of flight, should show comparatively low agonistic levels and expend as much energy as possible in mate searching and courtship. This prediction is borne out. (The exception, *I. deropeltiformis,* may be explained by the fact that females were very rare in the population [Gorton, 1980] and may be sufficiently limiting to select for high agonistic levels. Indeed, *I. deropeltiformis* was highly agonistic in general. This may be due to the fact that it occurs in the same habitat with *P. lata,* which is of similar size and has similar habits. Interspecific competition may account for the small population size seen in the field as well as the intensity of agonism.) A further contributor to high agonistic levels in females is oothecal parasitism (Roth and Willis, 1960). A high density of oothecae in an area may encourage a parasite to remain in the area, resulting in a high loss in reproductive fitness. In contrast to *Parcoblatta,* blaberid males are more intensely agonistic than blaberid females (Ewing, 1972; Bell et al., 1978, 1979; Gorton et al., 1979). Blaberid females carry their oothecae internally, freeing them from parasitism and other environmental vicissitudes. It appears that sexual selection through male-male competition for mates is a dominant selective force in high male agonism: Blaberid females are virtually passive and,

in at least one species, *Eublaberus posticus,* tend to mate with the first male they encounter. Thus, there is a definite advantage to the male that can chase other males away (Gorton et al., 1979). Ewing (1973) reported a similar situation in *Nauphoeta cinerea.*

Informational Analyses

The acts transmitting the least information from the initiator of an encounter to the responder in females are involved in initiating the encounter ("approach") and in the gathering of sensory information ("antennate"). "Lunge" and "climb" contain the most information for males and females. The acts carrying the least information in male responders were low intensity acts: "does nothing" and "antennate." In females, however, the acts carrying the least amount of information are rather intense: "stilt-kick" and "kick." A great deal of information directed from the responder to the initiator is contained in "lunge" and "antennate" in females and in "lunge" and "stilt" in males. In the wood cockroaches, then, "lunge" is usually a very decisive act for either sex, while "does nothing" makes the response almost independent of this act. It may be that "does nothing" is a spacer, i.e., an organism that responds neither agonistically nor retreats may be waiting for further information about the other individual and gains time by not reacting at once and reveals little about its drive state. It is noteworthy that "antennate" carries little information from the initiator to the responder in females, but a great deal is carried by this act in the opposite direction. "Antennate" by the responder often occurs as its first act, signalling to the initiator that it is not prepared to immediately decamp without first assessing the approaching individual. That this at least sometimes pays off is supported by the fact that "truce" is an act perpetrated by the initiator, which allows the responder to stay in the vicinity with at least temporary safety from attack.

Compared with other cockroach genera, "approach" carries less information in *Parcoblatta* and *Ischnoptera* males than in males of *Blaberus discoidalis, Leucophea maderae, Periplaneta americana, Byrsotria fumigata,* and *Diploptera punctata,* and "stilt" is of greater determining power in wood cockroaches than in any of the species mentioned (Bell et al., 1979). (These comparisons were made by comparing the wood cockroach with the least diversity for the act in question with the species in the above mentioned group with the least diversity for the same act, and so on.) When compared with *Shawella coloniana,* the wood cockroaches displayed greater determining power for a given act (Gorton et al., unpubl.). Of the species whose behavior has been analyzed with information theory, *Nauphoeta cinerea* is the only one in which analogous acts have greater determining power, perhaps due to the high degree of social structure in this species (Ewing, 1972, 1973; Bell and Gorton, 1978). There must, however, be a high selective value on efficiency of signals in the wood cockroaches compared to most other species, irrespective of their social structure. The high encounter rates, both intra- and interspecific, of these free-moving species may have placed a premium on efficient, unambiguous signals.

Generally, the responder transmits more information to the initiator of an encounter than vice versa, often twice as much and in *P. pennsylvanica* males, three times as much. *Parcoblatta pennsylvanica* females, however, transmitted roughly equal amounts of information in both directions, and *I. deropeltiformis* males transmit more information from the initiator to the responder. These indices support the notion that initiators are seeking information about the responders and at the same time

may want to reveal as little about themselves as possible. It appears that the responder is largely responsible for the nature of the encounter, and its initial response to contact from a conspecific will determine the intensity, length, and information content of the exchange.

ACKNOWLEDGMENTS

We thank Drs. K. B. Armitage, C. D. Michener, D. W. Roubik, Mr. P. G. Decelles, and Mr. M. K. Tourtellot for various forms of assistance throughout this study. This paper is part of a doctoral dissertation submitted to the Department of Entomology at the University of Kansas by the senior author.

LITERATURE CITED

BELL, W. J., AND R. E. GORTON, JR. 1978. Informational analysis of agonistic behavior and dominance hierarchy formation in a cockroach, *Nauphoeta cinerea*. Behaviour 57:217-235.

BELL, W. J., R. E. GORTON, JR., M. K. TOURTELLOT, AND M. D. BREED. 1979. Comparison of male agonistic behavior in five species of cockroaches. Insectes Sociaux 26:252-263.

BELL, W. J., S. ROBINSON, M. K. TOURTELLOT, AND M. D. BREED. 1978. An ethometric analysis of agonistic behavior and social hierarchies in the cockroach, *Eublaberus posticus*. Z. Tierpsychol. 48:203-218.

BROWN, J. L. 1964. The evolution of diversity in avian territorial systems. Wilson Bull. 76:160-169.

EWING, L. S. 1972. Hierarchy and its relation to territoriality in the cockroach, *Nauphoeta cinerea*. Behaviour 42:152-174.

———. 1973. Territoriality and the influence of females on the spacing of males in the cockroach, *Nauphoeta cinerea*. Behaviour 45:287-304.

GORTON, R. E., JR. 1979. Agonism as a function of relationship in a cockroach, *Shawella couloniana* (Dictyoptera: Blatellidae). J. Kansas Entomol. Soc. 52:438-442.

———. 1980. A comparative ecological study of the wood cockroaches in northeastern Kansas. Univ. Kansas Sci. Bull. 52:21-30.

GORTON, R. E., JR., J. FULMER, AND W. J. BELL. 1979. Spacing patterns and dominance in the cockroach, *Eublaberus postieus* (Dictyoptera: Blaberidae). J. Kansas Entomol. Soc. 52:334-343.

MCKITTRICK, F. A. 1964. Evolutionary studies of cockroaches. Cornell Univ. Ag. Expt. Station Memoir 389. 194 p.

ROTH, L. M., AND E. R. WILLIS. 1960. The biotic associations of cockroaches. Smithsonian Misc. Coll. 141:1-470.

STEINBERG, J. B. 1977. Information theory as an ethological tool, p. 47-74. *In* B. A. Hazlett (ed.), Quantitative Methods in the Study of Animal Behavior. Academic Press, N.Y.

STEINBERG, J. B., AND R. C. CONANT. 1974. An informational analysis of inter-male behavior of the grasshopper *Chortophaga viridifasciata*. Anim. Behav. 22:617-627.

WALTHER, J. B., AND E. DODT. 1957. Elektrophysiologische Untersuchungen über die Ultravioletempfindlichkeit von Insektaugen. Experientia 13: 333-334.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

THE CRANE FLY GENUS *CHIONEA* IN NORTH AMERICA

By
George W. Byers

Vol. 52, No. 6, pp. 59-195 March 18, 1983

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

COMP. ZOOL. LIBRARY
APR -5 1983
UNIVERSITY

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 6, pp. 59-195 March 18, 1983

THE CRANE FLY GENUS *CHIONEA* IN NORTH AMERICA[1]

George W. Byers

Contents

Introduction 60
Acknowledgments 60
The Genus *Chionea* 61
North American *Chionea* 62
Historical Review 64
Materials and Methods 64
Adults—External Morphology 66
Adults—Internal Morphology 78
Natural History of *Chionea* 94
Ecological Distribution 94
Geographical Distribution 98
Seasonal Distribution 99
Longevity of Adults 100
Behavior 100
Mating Behavior 104
Parasites and Predators 105
Immature Forms of *Chionea* 108
Eggs 108
Larvae 111
Pupae 120
Key to Males of North American *Chionea* 122
Key to Females of North American *Chionea* 124
The *C. scita* Group 126
C. albertensis Alexander 126
C. macnabeana Alexander 131, 195
C. nivicola Doane 133
C. scita Walker 138
C. wilsoni, new species 142, 191
The *C. valga* Group 142
C. hybrida, new species 142
C. obtusa, new species 145
C. stoneana Alexander 149
C. valga Harris 154
The *C. alexandriana* Group 162
C. alexandriana Garrett 162
C. carolus Byers 169
C. durbini, new species 172
C. excavata, new species 175
C. jellisoni, new species 179
C. lyrata, new species 183
C. nigra, new species 186
Literature Cited 189
Appendix 1: *C. wilsoni*, new species 191
Appendix 2: Male of *C. macnabeana* 195

[1] Contribution No. 1780 from the Department of Entomology, The University of Kansas, Lawrence, Kansas 66045, U.S.A.

ABSTRACT

This is primarily a taxonomic revision; eight new species of nearctic *Chionea* are described: *durbini, excavata, hybrida, jellisoni, lyrata, nigra, obtusa* and *wilsoni. Chionea noveboracensis* Alexander is placed in synonymy of *C. valga* Harris. These changes result in recognition of 16 North American species. The earlier grouping of species based on number of flagellomeres is rejected, and three species groups based on genital and other characters of both sexes are recognized. Separation of *Niphadobata* Enderlein from *Chionea* is rejected.

Morphological adaptations of *Chionea* for loss of wings and a largely subterranean life are examined. External anatomy and internal anatomy of the adult flies are described. The eggs, larvae and pupae are briefly described, including internal anatomy of the larva.

Ecological relationships of *Chionea* to the physical environment and to other organisms are discussed. In particular, the temperature range within which *Chionea* is active on the snow and the flies' survival in extreme cold are explored. Various species of *Chionea* are shown to transport phoretic nematodes and to serve as intermediate hosts of mouse tapeworm. Geographic distribution of the species is correlated with latitude, elevation and plant cover.

INTRODUCTION

Among the more curious of the thousands of known species of Tipulidae are the little wingless snow flies that comprise the genus *Chionea*. Their peculiar, spider-like appearance and unusual occurrence as adults in winter have long made them subjects of comment by entomologists; however, the fact that they are abroad when most people are inclined to remain indoors has discouraged the collection of many specimens or of detailed information about their life histories and activities. Several species have been recognized and described, and occasional field observations of the living insects have been made, yet our fundamental knowledge of the genus remains fragmentary. Nearly every paper published on *Chionea* in North America has been based upon the chance discovery of one or two specimens; in fact it was precisely such a discovery of a mere five individuals that prompted my own investigation of these insects.

This study has been rather unsatisfying in certain respects, largely because of the difficulty of finding *Chionea* either alive in its natural surroundings or preserved in collections. Only about 1100 adult specimens could be brought together from all sources, and the distribution of these among the various species is extremely uneven. Moreover, I have rarely had the opportunity to observe living adults. The immature instars of *Chionea* have been encountered only two or three times in Europe, and only twice in North America. Because of this rarity of specimens, intraspecific variation has not been well understood in the past, with the result that the taxonomy of *Chionea* has been in certain instances confused. The long-standing misinterpretation of certain details of their external and internal anatomy may also be due to this rarity of specimens for study.

In view of these circumstances, it seems to me worthwhile to bring together and reorganize the accumulated facts about *Chionea*, adding to them such things as I have been able to learn about the morphology, natural history and taxonomy of the genus. Perhaps what follows also will serve to stimulate further interest in these flies, which may some day lead to a more complete treatment of them.

ACKNOWLEDGMENTS

Several people have contributed to this undertaking in various ways, and the help of all is appreciated. For early encouragement in the study of *Chionea*, I am indebted to the late Prof. J. Speed Rogers of the Univ. of Michigan; and for helping in many ways, especially by making available the types of his species of *Chionea*, I thank Prof. Emeritus Charles P. Alexander of Amherst, Massachusetts. I am indebted to eight hardy entomologists, in particular, for making the major collections of *Chionea* studied: Dr. M. S. Bris-

coe, Howard Univ.; Dr. John A. Chapman, then of Montana State Univ.; Mr. David V. Durbin, San Francisco, California; Mr. Roger A. Haick, then of the Univ. of Montana; Dr. William L. Jellison, Hamilton, Montana, formerly of the Rocky Mountain Laboratory, U. S. Public Health Service; Dr. William S. Osburn, then of the Univ. of Colorado; Mr. David S. Potter, Univ. of Montana; and Mr. Gary A. Shook, Boise, Idaho. I wish to thank the following curators and others for the loan of specimens: William F. Barr, Univ. of Idaho; Sydney G. Cannings, Univ. of British Columbia; P. J. Darlington, Museum of Comparative Zoology, Harvard Univ.; Henry Dietrich and L. L. Pechuman, Cornell Univ.; Paul Freeman, British Museum (Natural History); Maurice T. James and William J. Turner, Washington State Univ.; Edward L. Kessel and Paul H. Arnaud, Jr., California Academy of Sciences; Hugo G. Rodeck, Univ. of Colorado; Herbert H. Ross and Donald W. Webb, Illinois State Natural History Survey; Herbert J. Teskey and Guy E. Shewell, Entomology Research Institute, Canada Department of Agriculture; Alan Stone, USDA, U. S. National Museum; and John A. Wilcox, New York State Museum. I am particularly grateful to Dr. Ryuichi Matsuda and Dr. Herbert J. Teskey for constructive criticism of respectively the morphological and all other parts of this paper. Finally, I thank all others who have sent specimens of *Chionea* during this study, for every specimen has been a substantial addition.

Generous support for part of this work by National Science Foundation grants G-9236 and DEB-77-15868 is gratefully acknowledged.

The Genus Chionea

Chionea is a small genus of only about two dozen species, widely scattered about the Holarctic region, 16 occurring in North America and the others in Europe, far eastern U.S.S.R., and Japan. Although these species exhibit considerable variation in anatomical details, they have an overall similarity that involves a number of conspicuous specializations (such as extreme modification of the thorax), imparting to the genus the appearance of structural homogeneity and at the same time so setting it apart from other genera that it is not easy to conceive of a more "natural" group. In spite of this, the most recent revision of the European species (Burghele-Bălăcesco, 1969) recognizes separate genera, *Chionea* and *Niphadobata*, for species groups differing in structure of the aedeagus of the male and in details of the antennae. Enderlein (1936: 19) had based *Niphadobata* on the number of antennal segments (6-7, compared to 9-10 in typical *Chionea*). Kratochvil (1936: 250) found that most flagellomeres in the species with longer antennae (*longicornae* group) have four verticillar hairs while those in the other group (*brachycornae*) have three. He also noted that in the *longicornae* group the aedeagus is shorter than the gonapophyses and has small basal parameres, in contrast to the condition in the *brachycornae*, in which the aedeagus is longer than the gonapophyses and has no basal parameres.

Some North American species of *Chionea* bridge the gap in number of antennal segments, as discussed below, and the difference in number of verticillar hairs does not hold for our species. Three verticillar hairs is the usual number in nearctic species with short antennae, for example, *C. alexandriana*, which has three flagellomeres. But three is also the usual number in *C. scita* and *C. albertensis*, which have respectively eight and ten flagellomeres, on the average, and also in those species having an intermediate number of flagellomeres. The number of such hairs is not constant within a species, however, and one or two flagellomeres

may have four hairs while others of the same antenna have three.

None of the nearctic species belongs to the typical European group on the basis of short aedeagus with basal finger-like parameres; thus, there is no correlation whatsoever of aedaegal structure with length of antennae. Furthermore, I am inclined to reject the division of *Chionea* into two genera on this basis because to do so ignores the great number of structural specializations of the thorax, legs, wings, halteres and abdomen that all the species have in common.

I have yet to see a key to the Diptera that will identify a specimen of *Chionea* as a tipulid. Its winglessness (actually it has tiny vestiges of wings) and stout body render it an unlikely candidate for offhand inclusion with other crane flies, and it lacks the V-shaped transverse mesonotal suture by which supposedly all Tipulidae may be known from similar flies in other families.[2] Its broad sternum separates the coxae widely, and when the antenna are greatly reduced, as happens in certain species, the inexperienced entomologist might suspect that *Chionea* belongs among the Pupipara. The genus was, in fact, placed in a separate family for a time during the middle 1800's by such eminent dipterists as Rondani, Zetterstedt and Bigot (e.g., Rondani, 1856: 38, 189). By 1869, however, Osten Sacken showed the eriopterine affinities of *Chionea* and moved the genus near to its currently accepted systematic position. Allowing for the moment that *Chionea* belongs somewhere among the Tipulidae, it must further be placed in the subfamily Limoniinae, on the basis of the short terminal segment of the maxillary palps and the structure of the ovipositor, which is unlike the form found in the Tipulinae or Cylindrotominae. The placement of the genus in the tribe Eriopterini is based upon the following combination of characters:

1. eyes without short hairs interspersed among the facets, such as are found in the Pediciini, some of which are wingless.
2. tibiae without spurs.
3. pretarsal claws not toothed.
4. empodia well developed in form of arolia.

Certain genera of the Eriopterini exhibit some of the unusual structural characteristics of *Chionea*, as, for example, the fusion segment at the base of the antennal flagellum or the undivided dististyles on the male genital segment. Accordingly, Alexander (1916: 530) regarded *Chionea* as a specialized relative of these genera, *Cladura* and *Pterochionea* (now regarded as a synonym of *Cladura*), in a subtribe later designated the Cladurariа, to which group the European *Crypteria* and American *Neolimnophila* also belong. Subsequent comparison of the immature forms of *Chionea* and *Cladura* has strongly supported Alexander's placement of the genus near to *Cladura*.

North American Chionea

Although aware of some differences between Old World and American Chioneas, I do not believe the North American species can yet be distinguished as a group from their Eurasian relatives. I have studied the palearctic species only sufficiently to say that little more is known about them than about the American forms, except that their taxonomy has recently been revised in a detailed and excellently illustrated publication by Anca Burghele-Bălăcesco (1969).

Thirteen North American species of *Chionea* have been described: *C. alberten-*

[2] Marchand (1917: 151) discovered an indication of taxonomic affinity that nearly everyone else seems to have overlooked: "One of the . . . specimens (of *Chionea*) . . . was found to have lost all its legs during transportation, showing . . . in this peculiarity its relationship to the Tipulids." See also Ainslie (1906).

sis Alexander, *C. alexandriana* Garrett, *C. aspera,* Walker, *C. carolus* Byers, *C. gracilis* Alexander, *C. macnabeana* Alexander, *C. nivicola* Doane, *C. noveboracensis* Alexander, *C. primitiva* Alexander, *C. scita* Walker, *C. stoneana* Alexander, *C. valga* Harris, and *C. waughi* Curran. *Chionea aspera* has long been recognized as a synonym of *C. valga,* and although *C. scita* was also regarded as a synonym of *valga* for many years (Alexander, 1942: 429) I have considered it a valid name, with *C. primitiva* its synonym (Byers, 1963: 160). On the basis of my opinions expressed in correspondence with him, Alexander (1965: 72) placed *C. gracilis* and *C. waughi* in the synonymy of *valga.* These rearrangements in the Catalog of the Diptera of America North of Mexico (Stone et al., 1965) should have been noted as new synonymy. I further regard *C. noveboracensis* as a synonym of *valga.* To the remaining list I shall here add eight previously undescribed species, bringing the total to 16.

Species heretofore described have been differentiated largely on the basis of color, size, and number of antennal segments. In the following revision, however, I shall try to show that these characters, while useful for the differentiation of species groups, have only limited utility in the diagnosis or recognition of the species. The most consistently useful characters for species recognition are the shapes of the gonapophyses in the male, and of the ovipositor and associated sclerites in the female; less commonly, another character may by some peculiarity prove to be wholly reliable.

Many tipulid genera have been divided into subgenera—a practice widely adopted in the taxonomy of nematocerous Diptera. Although this has not been done in the case of *Chionea,* two major species groups were proposed by Kratochvil (1936: 250) for the European species: *Chioneae longicornae,* including those species with nine or ten antennal segments; and *Chioneae brachycornae* (emended to *brachycerae* by Alexander, 1940: 101), including species that have six or seven antennomeres. Enderlein (1936: 19) gave the *brachycornae* generic status, as *Niphadobata,* but this name has not been consistently applied in the more recent literature (cf. Burghele-Bălăcesco, 1969). In classifying the North American Chioneas, Alexander (1941: 212) adopted species group names, respectively *araneoides* group for the *longicornae* and *valga* group for the *brachycerae.* While I have retained the *valga* group in my classification, it is based upon a combination of characters as set forth below. In the North American species there is continuous variation in number of antennal segments from four (i.e., scape, pedicel, fusion segment and one additional flagellomere) to 12, the number for any species varying often by one, rarely by two, exceptionally by more than two. I have therefore abandoned the older classification in favor of the following, applicable to the North American species only:

1. *scita* group—general body color yellowish brown or brown; antennae of 10-12 segments; gonapophyses of male bladelike, without upturned apical hook; eighth abdominal tergum of female short (much less than half length of seventh tergum, measured front to rear); includes *scita, albertensis, nivicola, wilsoni* n. sp., and *macnabeana.*

2. *valga* group—general body color reddish brown, grayish brown or dark brown; antennae of 5 (rarely 4) to 9 segments; gonapophyses of male in form of a horizontal blade with a vertical keel, without apical hook; eighth abdominal tergum of female longer, about half length of seventh tergum; includes *valga, stoneana, hybrida* n. sp., and *obtusa* n. sp. Inclusion of *stoneana* and *hybrida* here is based primarily on the structure of the gonapophyses. The other species as a group have 7-9 antennal segments, as contrasted with

4 or 5 in *stoneana* and *hybrida*, and the eighth tergum in females of *stoneana* and *hybrida* is lengthened only at the sides, appearing short in dorsal aspect.

3. *alexandriana* group—general body color light brown, brown, dark brown or black; antennae of 5 (rarely 4) to 7 segments; gonapophyses of male broad at base, slender, upturned and hook-like at apex; eighth abdominal tergum of female much shorter than half length of seventh tergum; includes *alexandriana, carolus, durbini* n. sp., *excavata* n. sp., *jellisoni* n. sp., *lyrata* n. sp., and *nigra* n. sp.

Historical Review

The genus *Chionea* was established in 1816 by J. W. Dalman for a northern European species, *C. araneoides*, which is type species of the genus by monotypy. Thaddeus Harris described the first North American species, *C. valga*, in 1841, though as early as 1833 he had mentioned the occurrence of the genus in Massachusetts and in 1835 named the species without describing it. Two North American species were shortly afterward described by Francis Walker, *Chionea aspera* (a synonym of *valga*) and *C. scita* (Walker, 1848).

No additional North American species were discovered then for over 50 years. In 1900 R. W. Doane named the first species from western North America, *C. nivicola*. Charles P. Alexander in 1917 described *C. gracilis* and *C. noveboracensis* (both here regarded as synonyms of *valga*), and *C. primitiva* (a synonym of *scita*). C. B. D. Garrett named the second species from the West, *C. alexandriana*, in 1922; and in 1925 C. H. Curran described *C. waughi* (synonymous with *valga*).

Subsequent additions to the list of American species have been the work of C. P. Alexander and include *C. stoneana* (1940), *C. albertensis* (1941), and *C. macnabeana* (1946).

References to North American *Chionea*, other than these of a purely taxonomic nature, have been in general limited to a few brief notes on casual observations of the adults. Nothing has so far been published on the biology or life history of these flies except by John Chapman (1954: 360-363), who discussed the ecological and seasonal distribution of some western species and described their activities at various temperatures.

Mention should be made of the work of Jacques Bitsch (1955), which deals with European species but offers the only modern treatment of the external anatomy of *Chionea*, and of Anca Burghele-Bălăcesco (1969), concerning taxonomy of the European species based upon careful study of the genitalic anatomy.

Because of its extreme structural modification, *Chionea* has been accorded varying degrees of special taxonomic status by various dipterists. Rondani (1841: 284) early regarded it as in a separate "familia," Chioneinae, and Zetterstedt (1842: 104) gave the genus apparent family status as Chioneides. Bigot (1854: 466) also placed the genus in a separate family, Chioneidae. However, Osten Sacken (1869: 136) noted the many similarities between *Chionea* and certain other crane flies and arranged it with the Eriopterina (now tribe Eriopterini), where it remains today. More recently, nevertheless, Williston (1908: 86) separated all the Limnobiinae (now Limoniinae) into tribes, except for *Chionea*, left standing alone as a genus. Burghele-Bălăcesco (1969) recognized two genera, *Chionea* and *Niphadobata*, for the European species, following Enderlein (1936) but with firmer morphological basis.

Materials and Methods

Taxonomic and morphological descriptions which follow are based upon the study of somewhat over 1100 specimens of adults of *Chionea*—all that could be located by a fairly thorough search of mu-

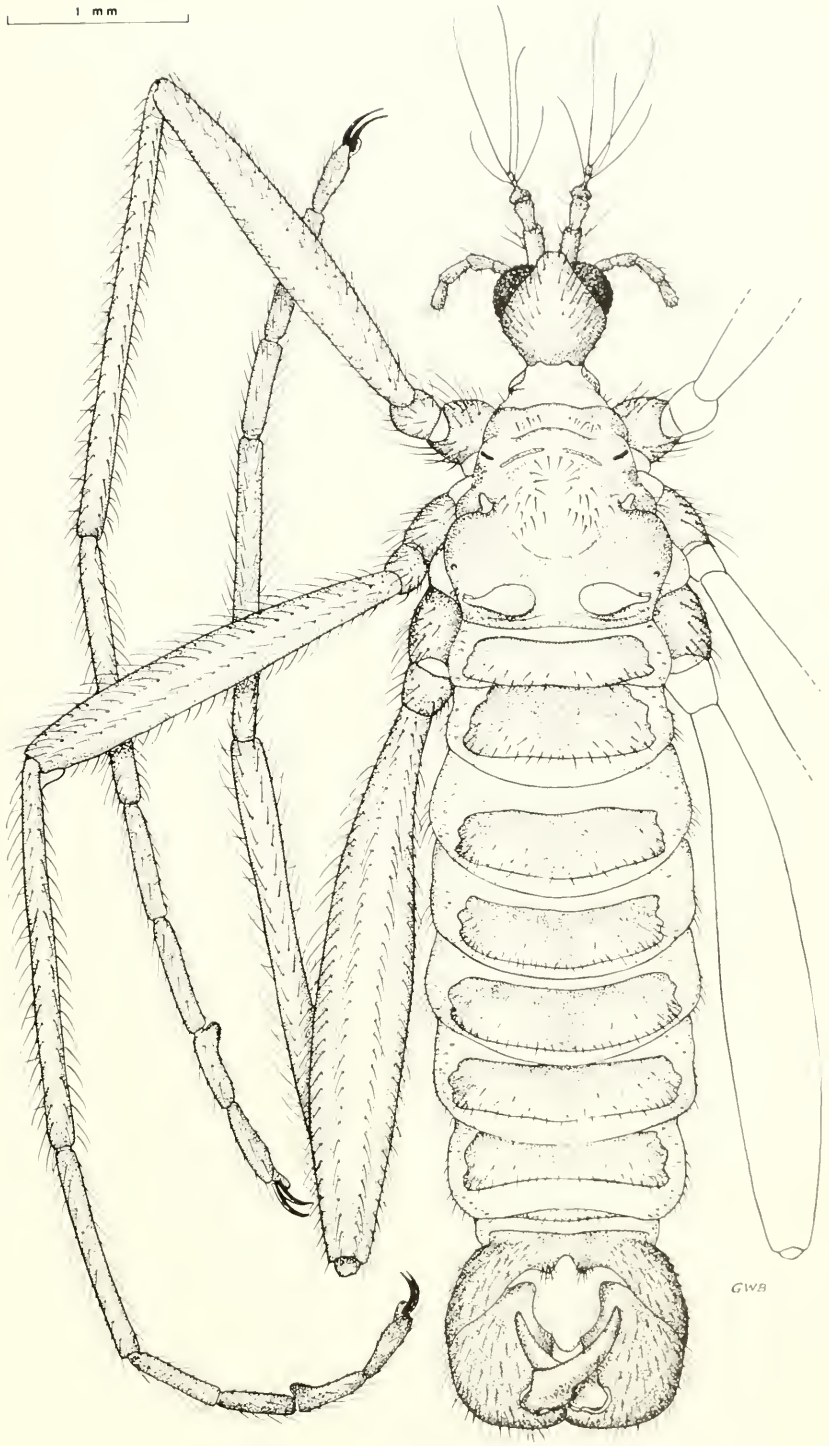


Fig. 1. *Chionea alexandriana* Garrett, male, dorsal aspect (most of right legs omitted), to show general habitus.

seums and other collections. These have included the holotypes or type series of all species except *C. noveboracensis* (type lost) and *C. alexandriana* (paratypes seen). The only immature forms studied were those of *Chionea valga* and *C. stoneana*. These will be described in detail in a separate paper, and only the latter are dealt with here in a general way.

Although numerous flies pinned dry have been seen, a greater number have been preserved in alcohol, the latter by far the more satisfactory specimens. Chioneas generally make pretty wretched pinned specimens because of their small size and tendency to become shriveled and distorted when dried, such as in extreme telescoping of the abdominal segments. Not only does preservation in fluid keep the insects in more or less their original shape and dimensions, but it also permits subsequent study of the internal structures and greatly facilitates identification, for the gonapophyses of the male are readily exposed by pressing the membranous tenth abdominal segment forward beneath the ninth tergum, and the ovipositor of the female is easily opened to reveal the shape of the ninth abdominal sternum and the genital furca.

Specimens mounted on microscope slides were first cleared in 10% potassium hydroxide, then washed in increasing concentrations of ethyl alcohol (80%, 95%, absolute), then in xylene, and finally cleared somewhat further in clove oil. All were examined "in the round" before being mounted in Euparal medium.

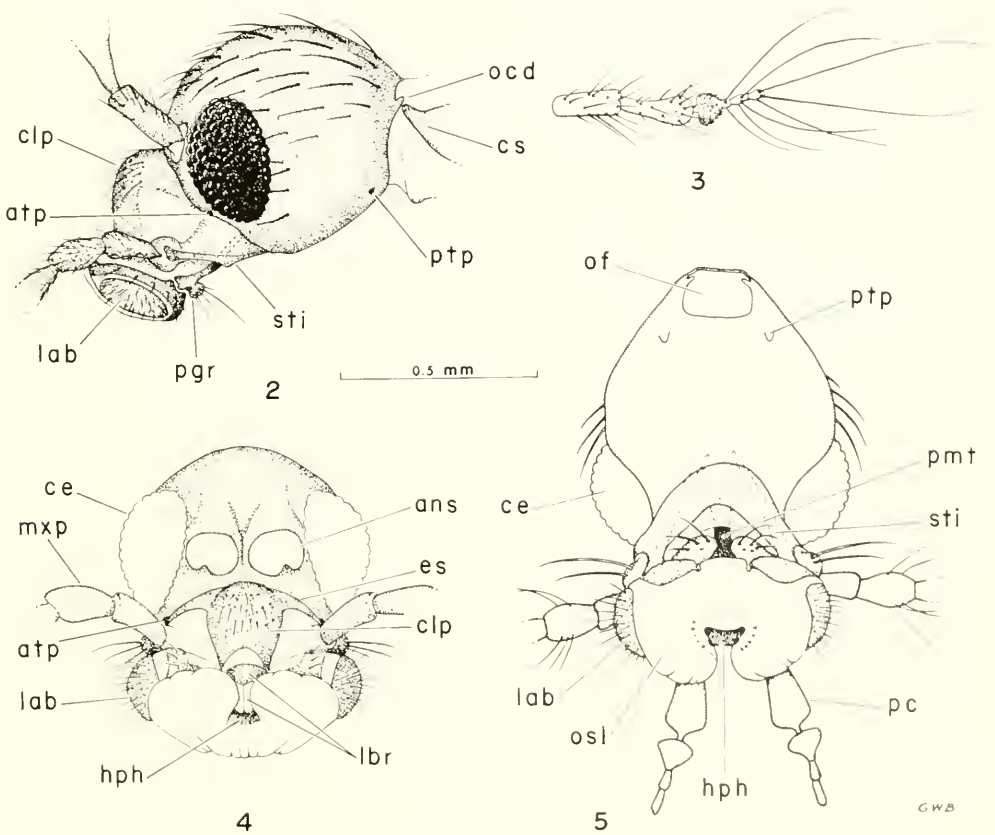
Morphological studies were based upon flies preserved in 70-80% ethyl alcohol. There are, of course, better fixing solutions for muscle and internal organs, but alcohol suffices; besides, few Chioneas have ever been collected specifically for morphological examination.

ADULTS—EXTERNAL MORPHOLOGY

General Description.—Being wingless and hairy and having a short body (Fig. 1) and short, stout legs (as compared to those of other tipulids), flies of the genus *Chionea*, when seen from a few feet away, superficially resemble spiders, a similarity suggested in the name of a European species, *C. araneoides*. They are small crane flies, their overall length, exclusive of the antennae, varying from about 3-8 mm, depending in part upon the species and the degree of abdominal contraction ("telescoping"), which is in turn dependent upon whether the insect is alive or not and if preserved whether dried or in fluid. There is also extensive size variation among individuals of the same species similarly preserved, as will be discussed later. General body coloration varies from pale to dark yellowish brown through reddish or grayish brown and dark brown to black but is fairly constant within a species; callow individuals are always somewhat paler than more fully matured adults.

Head.—Several structural details of the head of *Chionea* differ noticeably from their counterparts in other crane flies, the most striking being the antennae, which consist of scape, pedicel and a variable number of flagellomeres. The nearly cylindrical scape bears a few scattered setae on its dorsal surface, fewer or none ventrally, before an irregular subapical whorl (Figs. 2, 3). Subequal in length to the scape, the peculiarly elongated pedicel is narrowed at its base but expanded in the distal half; it bears a fairly distinct verticil of 10-12 setae slightly before the segment begins to narrow toward the flagellar attachment and a scattering of other setae in no apparent pattern. While the number of flagellomeres is rather constant in most tipulid genera, it varies at least from 2-10, mostly according to species, in *Chionea*. This, of course, attracted the attention of taxonomists long ago and understandably became one of the first criteria for species recognition. The first flagellar "segment" is much thicker than

the others and has a subconical or turbinate shape (Fig. 3), while the second and succeeding segments are elongate and of more uniform diameter. Since among the Eriopterini in general the number of flagellomeres is 14, the enlarged first segment in *Chionea* is judged to have originated by fusion of some greater number of segments, varying 5-13 as the number of segments beyond it diminishes correspondingly from 9-1. This first segment is accordingly known as the fusion segment, and although it cannot clearly be seen to comprise more than one segment in *Chionea* (but see C. W. Johnson's comment in Alexander, 1917: 202), its structure in the closely allied *Cladura* (formerly *Pterochionea*) *bradleyi* (Alexander), showing five distinct verticils, seems to substantiate this interpretation. I have compared the antennae of *Chionea scita* and *Cladura bradleyi* (as *Pterochionea*) in another paper (Byers, 1961*a*: 190-191). The fusion segment is densely pitted and clothed with short hairs except on its base. Occasionally, especially in species of the *alexandriana* group in which there is greatest reduction of the antennae, there will be found a long seta or two attached near the apex of the fusion segment. In the *scita* group the second flagellomere (first beyond the fusion segment) is covered



Figs. 2-5. *Chionea alexandriana*, details of head. 2, head, left lateral aspect. 3, right antenna, dorsolateral aspect. 4, head, frontal or facial aspect (antennae removed). 5, head, ventral aspect. Abbreviations: ans—antennal socket, atp—anterior tentorial pit, ce—compound eye, clp—clypeus, cs—cervical sclerite, es—epistomal suture (sulcus), hph—hypopharynx, lab—labial palp, or labellum, lbr—labrum, mxp—maxillary palp, ocd—occipital condyle, of—occipital foramen, osl—oral surface of labellum, pc—pedicel of antenna, pgr—palpiger of labial palp, pmt—prementum, ptp—posterior tentorial pit, sti—stipes of maxilla.

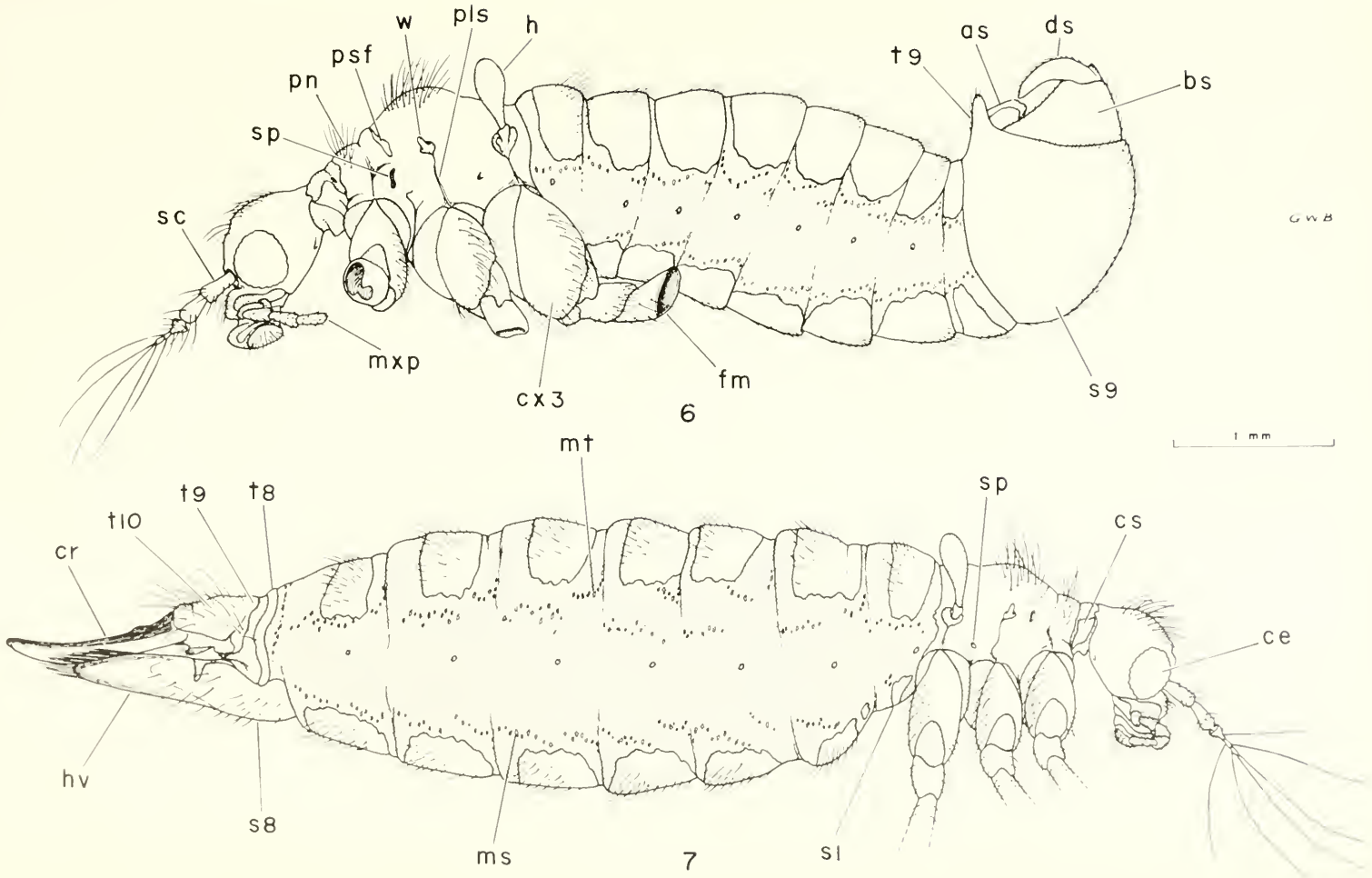
with short hairs similar to those of the fusion segment. The other flagellomeres have three, or rarely four, long setae arranged in irregular whorls. In general, these verticils increase in length as the number of flagellomeres is reduced, as if to compensate for the reduction and maintain antennal length (e.g., compare Fig. 3 with 97). This may be an instance of what Matsuda (1979: 220) has called material compensation, such compensatory development often being seen in insects with reduced wings (p. 224).

The compound eyes are black in the living flies and often retain this color in preserved specimens. They are composed of about 80-200 ommatidia, the number varying generally according to species but also somewhat among individuals within a species, without any evident sexual dimorphism. They occupy a comparatively smaller portion of the head surface than in most Tipulidae, a reduction in size that may be related to the largely subterranean habits of *Chionea*. It has been observed that subterranean and cavernicolous insects often have not only smaller compound eyes than their nearest relatives living above ground but also larger ommatidia, which perhaps are more efficient in gathering light in parts of the environment where some light is available. To see how this might apply in the case of *Chionea*, I compared the compound eyes of male specimens of *Chionea valga* and the related *Cladura flavoferruginea* of approximately equal body size and head dimensions. In the slightly larger eye of *Chionea* there were nine facets (3 × 3) within a sample unit square, whereas the *Cladura* had 16 (4 × 4), a 78% greater number of ommatidia per unit area in the day-flying *Cladura*. The size and number of ommatidia in most other species of *Chionea* are rather close to those in *C. valga*. Ability to perceive form clearly, it seems, would be of little use to a slowly moving, non-flying insect such as *Chionea;* on the other hand, living as it does in darkened recesses beneath the ground and coming onto the surface primarily at times of low light intensity, it would derive some benefit from eyes adapted to making the most of what light there was.

Surface areas of the head such as genae, frons, vertex and occiput are indistinguishably fused, the only useful "landmarks" other than eyes and antennae being the tentorial pits, of which the posterior pair may easily be seen at about 125× magnification (Figs. 2, 5). The anterior tentorial pits (Fig. 4) are smaller and concealed in the epistomal (fronto-clypeal) suture, close beneath the eyes. The vertex bears a group of stout hairs, the longer ones of which are subequal in length to the scape.

The short, thick rostrum is made up of the strongly arched clypeus in front and a posterior (ventral) sclerotized area in which the stipites of the maxillae are embedded (Fig. 2) and which is slightly inserted under the antero-ventral margin of the head, to which it has a membranous connection. Although joined by this sclerotization, the stipites are not fused medially as in tipuline crane flies, such as *Dolichopeza* (Byers, 1961*b*: 684, Fig. 9). Except for the stipes, the maxilla consists only of a five-segmented palp, of which the first segment is approximately spherical, the second elongate and somewhat curved, the third enlarged and having a more roughly

FIGS. 6, 7. *Chionea alexandriana*, external anatomy. 6, adult male, left lateral aspect (legs mostly omitted); as—anal (tenth) segment, bs—basistyle, cx3—coxa of metathorax, ds—dististyle, fm—femur (cut shortly beyond trochanter), h—haltere, mxp—maxillary palp, pls—pleural suture of mesothorax, pn—pronotum, psf—pseudosutural fovea, sc—scape of antenna, sp—spiracle (of mesothorax), s9—ninth abdominal sternum, t9—ninth abdominal tergum, w—wing rudiment. 7, adult female, right lateral aspect (legs mostly omitted): ce—compound eye, cr—cercus, cs—cervical sclerite, hv—hypovalve, ms—microsternite, mt—microtergite, sp—spiracle (of metathorax), s1—first abdominal sternum, s8—eighth abdominal sternum, t8, t9, t10—eighth, ninth and tenth abdominal terga.


w
pls
h
psf
pn
sp
sc
mxp
cx3
fm
t9
as
ds
bs
s9
6
GWB
1 mm
mt
t9
t8
t10
cr
hv
s8
ms
7
sp
cs
ce
sl

pitted surface (sensory structures?) than the others, and the fourth and fifth segments more elongate, as shown in Figures 2 and 6.

Partially telescoped beneath the maxillary bases is the strongly sclerotized prementun of the labium. It is forked at its inner (proximal) end, which extends into the head as an apodeme, and is slightly expanded distally where it adjoins directly the bases of the first labellar segments (Fig. 5). Over this junction lies a slightly sclerotized, setiferous lobe which I take to be a modification of the sclerite that in Tipulinae is interposed between the prementum and the first labellar segment. This sclerite has been called the palpiger by Rees and Ferris (1939: 147, Fig. 73) and, where divided, the "kappa" and "sigma" sclerites by Peterson (1916: 45-46, Plate XVII, Fig. 288). The labellar lobes are broad and dorsally clearly show division into two segments. Their ventral surfaces are remarkable in being quite smooth; that is, there are no pseudotracheae whatsoever (Fig. 5). At high magnifications, a row of tiny denticles can be seen near the meso-ventral margin of each lobe. These possibly are the equivalent of the prestomal teeth of certain higher Diptera (cf. Crampton, 1942: 36). The number of these denticles varies from 4-15, generally according to species, although it is not constant within a species. Closely appressed to the dorsal surface of the labium, in the deep notch between the labella, is the hypopharynx, which in *Chionea* extends far beyond the short labrum and, in the absence of labellar pseudotracheae, probably is used to take up liquid nutriment directly. The hypopharynx may be recognized by the compact brush of fine, golden hairs at its tip.

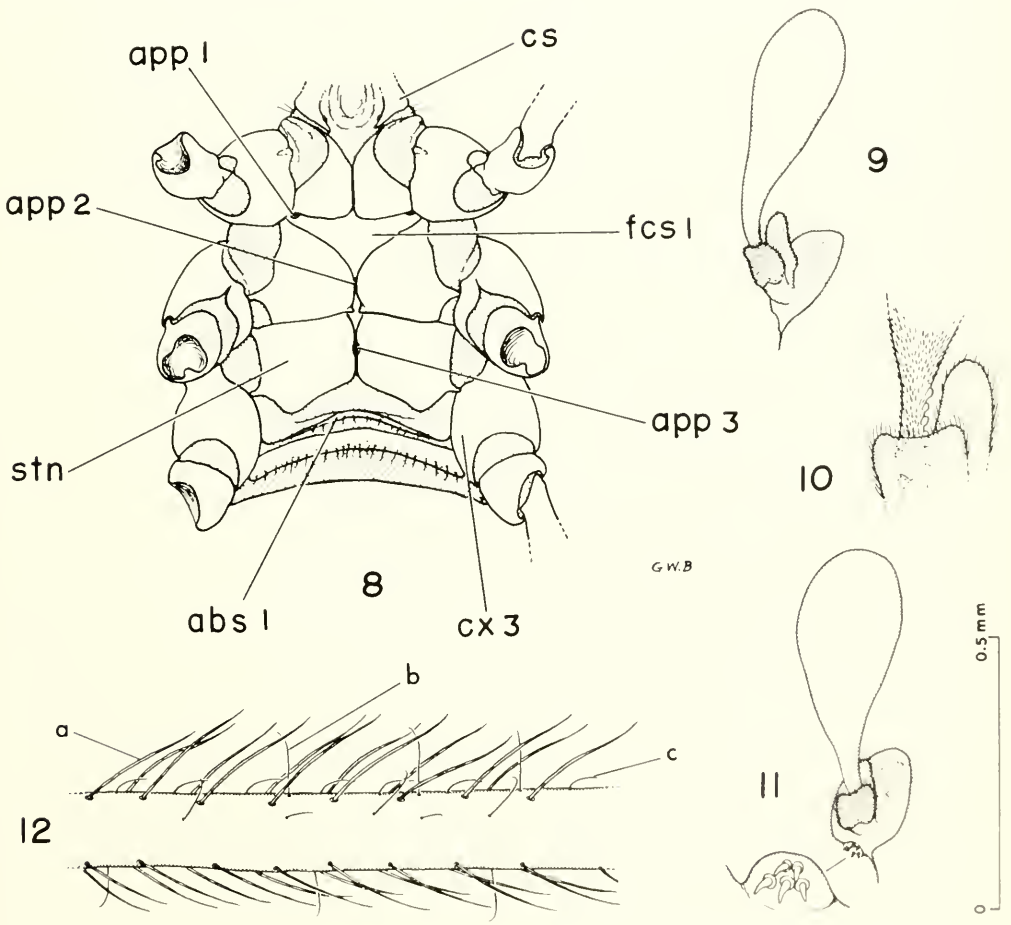
Thorax.—Loss of wings in *Chionea* has resulted in a corresponding diminution of the mesothorax, which, however, is still the largest thoracic segment. Wide and rather flat on the ventral side, the thorax is narrowed and arched above as shown by serial cross sections (Fig. 13, 14, 15) and increases in breadth from front to rear.

Since students of insect morphology cannot themselves agree on the interpretation of the thoracic sclerites, perhaps a mere taxonomist will be excused for making a somewhat arbitrary selection from among the available names for parts. Identification of thoracic areas in *Chionea* is complicated by the extensive fusion of dorsal and lateral sclerites and obliteration of many of the sutures that are fairly easy to discern in other tipulids. Using the coxae as reference points, however, it is not difficult to distinguish the three pleural sutures (Fig. 6, pls). The first of these (prothoracic) is in alignment with the junction between pronotum and mesonotum and terminates dorsally in a deep impression, which internally is the attachment of the sternal apophysis; and the second and third extend from the mesothoracic and metathoracic coxal processes, respectively, to the membranous areas about the bases of the vestigial wing and the haltere. Sclerotized areas before and behind these sutures may be identified as episternal and epimeral, respectively, but have no definite subdivisions (anepisternum, katepisternum, etc.), such as may be seen in the nearest relatives of *Chionea.* Crampton (1925: 201, 203) has commented on the reduction in *Chionea* of the mesothoracic meron, which in other genera of Eriopterini is large.

The pronotum, separated from the mesonotum by a fairly distinct suture, is crossed from side to side by an indistinct row of bristles. Two transverse, shallowly impressed, darkened spots on the mesonotum just above the slit-like mesothoracic spiracles (Fig. 6) appear to be the pseudosutural foveae. There is no differentiation of mesonotal prescutum, scutum, or scutellum, and the separation of mesothorax from metathorax is only weakly indicated dorsally by a shallow, transverse indenta-

tion and laterally by the position of the round metathoracic spiracles. Likewise, the nota grade imperceptibly into the pleural sclerites along the entire length of the thorax, the extensive, membranous paratergal areas seen in other tipulid genera being absent altogether (cf. Byers, 1961*b*: 687, Fig. 14).

In most crane flies, *Gnophomyia* being one exception, the coxae are set close together ventrally, and the mesosternum and metasternum are almost wholly infolded. By contrast, there are relatively broad ventral sclerites in *Chionea;* but the question arises—what is their identity? Are the sternal apophyses of the pterothorax ". . . carried inward upon a median inflection of the sternum to form the Y-shaped endosternal apodeme . . ." as stated by Snodgrass (1935: 171), or is it true that, as countered by Ferris (Rees and Ferris, 1939: 149), ". . . there is absolutely no sternal element visible externally on the thorax of any Dipteran . . ."



Figs. 8-12, *Chionea alexandriana,* details of thorax. 8, thoracic venter (legs mostly omitted): abs1—first abdominal sternum, app1—apophyseal pit of prosternum, app2—apophyseal pit of mesosternal furca, app3—apophyseal pit of metasternal furca, cs—cervical sclerite, cx3—coxa of metathorax, fcs1—furcasternum of prothorax, stn—sternum (combined basisternum and furcasternum) of metathorax. 9, haltere, posterior aspect. 10, detail of base of haltere, to show probable sensory structures. 11, haltere, lateral aspect; area of sensory pegs greatly enlarged. 12, *Chionea stoneana,* female, portion of hind tibia showing three kinds of setae (see text for explanation). Scale: Figs. 9, 11.

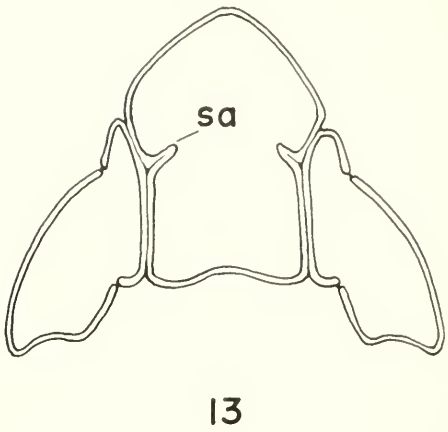
and that the apparent sternum is actually the subcoxal portion of the generalized insect leg, the endosternal apophyses (branches of the Y-shaped apodeme) being all that remain of the true sternum? It seems to me that Snodgrass and Ferris are in agreement that the ventral condyles articulating with the coxae belong to the subcoxal ring and that the sternal apophyses belong to the true sternum, so that what they are disputing is the location of the line of fusion between these two sclerites (cf. Snodgrass, 1935: 169, Fig. B, and Rees and Ferris, 1939: 165, Fig. 80c). In the cleared specimens of *Chionea* I have examined, as apparently also in many other Diptera, the line of fusion is not visible, its position therefore being hypothetical; consequently, there seems little to be gained by the argument. Rees and Ferris concede that what appears to be prosternum in *Tipula* is in fact the prosternum. If the same point of view is accepted for *Chionea,* then I would say that on the basis of structural similarity (Fig. 8) the meso- and metathoracic ventral sclerites are also sternal and that the Y-shaped sternal apophyses have been formed in these segments by the reduction of the furcasterna toward the ventral midline.

It is problematical why, in a dipteran that is altogether flightless, the halteres should be so well developed, but neither observation of the living flies nor microscopic examination of the structure of the halteres has led to an explanation. Except for the basal portion, or scabellum, the haltere is membranous and bladder-like (Figs. 9, 11) and covered with extremely fine hairs. The pedicel and capitellum, or knob, are not clearly divided. The capitellum seems to be hollow and in the living fly is probably filled with haemolymph. The scabellum comprises an incomplete cup, curving around the pedicel ventrally, and a longer dorsal lobe, both merging proximally on a slender, membranous attachment without any evidence of axillary sclerites. It is likely that the halteres in *Chionea* have some sensory function, for each has a fairly conspicuous nerve leading to it (but no visible tracheole), and on the base of the pedicel, mostly concealed within the scabellum, there are a dorsal and a ventral row of nodules, variable in number but most numerous dorsally, which probably are groups of sensilla (Fig. 10). There is also, at the edge of the episternum adjacent to the base of the haltere, a small swelling bearing a cluster of what appear to be sensory pegs (Fig. 11). It would seem that some movement of the halteres is involved in the stimulation of such sensory areas, but living Chioneas observed in the laboratory did not move the halteres noticeably, although, as will be discussed later, each has a small depressor muscle at its base.

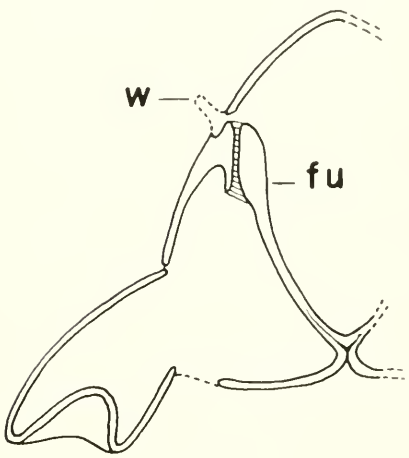
Little need be said about the vestigial wings (Figs. 6, 7). They are shorter than the scabellum of the haltere, slender, and completely membranous, without setae or any other trace of venation. Like the halteres, they appear to be hollow and to contain haemolymph; and they seem to be quite immovable.

The legs in *Chionea,* especially the coxae and femora, are stout as compared to those of other eriopterine crane flies. It may be seen in Figures 6 and 8 that the laterally projecting coxae are hinged on pleural and sternal condyles but that the extensive membranous areas about their bases allow them to turn in a wide arc, providing the freedom of movement required for an altogether pedestrian insect. In females and small males the femora are only slightly incrassate, but in the larger, more robust males they are not only of increased length but also of disproportionately greater thickness. For example, among specimens of *C. valga* collected at the same place on the same day, a representative small male had an overall body length (from antennal bases to tip of ab-

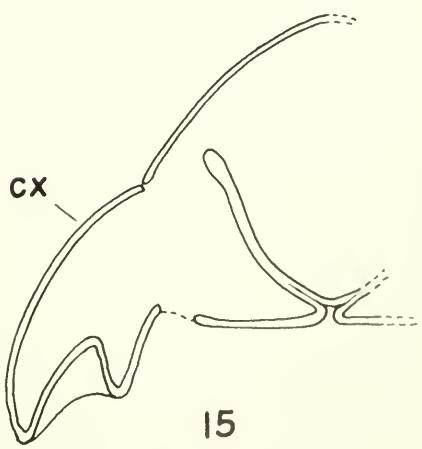
domen) of 3.3 mm, a large one, 4.7 mm, a ratio of 1 to 1.42; length of hind femur increased by a ratio of 1 to 1.76, while greatest width of the femur increased by a ratio of 1 to 2.00. At the same time tibial length increased only proportionately, at a ratio of 1 to 1.41. These specimens were preserved in alcohol, so non-uniform telescoping of abdominal segments was not a major factor in body measurement. (A similar example of disproportionate variation is described later, under *Chionea obtusa*.) Seen from the side, the femora are almost straight along the ventral edge but broadly arched dorsally, and near the base they are curved slightly outward from the body. This combination is what led Harris to name his species *valga* (i.e., "bow-legged"). The tibiae are more or less straight and of uniform diameter throughout, except that at the proximal end, or head, they are slightly narrowed and sufficiently curved to allow them to close against the femora. There are no tibial spurs, as in Eriopterini generally. Each of the first three tarsomeres is cylindrical, the basitarsus about equal in length to the succeeding four segments together and the second longer than the third (Fig. 1). In females the fourth segment has more or less the same shape as the third, but in males it has a hairy basal enlargement on the ventral surface (Figs. 1, 36). I have not been able to discover any functional significance of this lobe. The terminal segment is narrowed at its base and a little enlarged apically, bearing a pretarsus with two untoothed claws and an almost transparent, bladder-like arolium. While the basitarsus has an indistinctly dicondylic attachment to the tibia, all the other tarsal joints are formed by a single dorsal condyle



13



14



15

Figs. 13-15, *Chionea alexandriana*, cross-sections of thorax. 13, prothorax, at level of widely separated sternal apophyses (sa). 14, mesothorax, at level of wing (w), furca (fu) and pleural apophysis (joined to furca just below wing). 15, metathorax, at level of furca; cx—coxa.

inserted into a socket in the preceding segment.

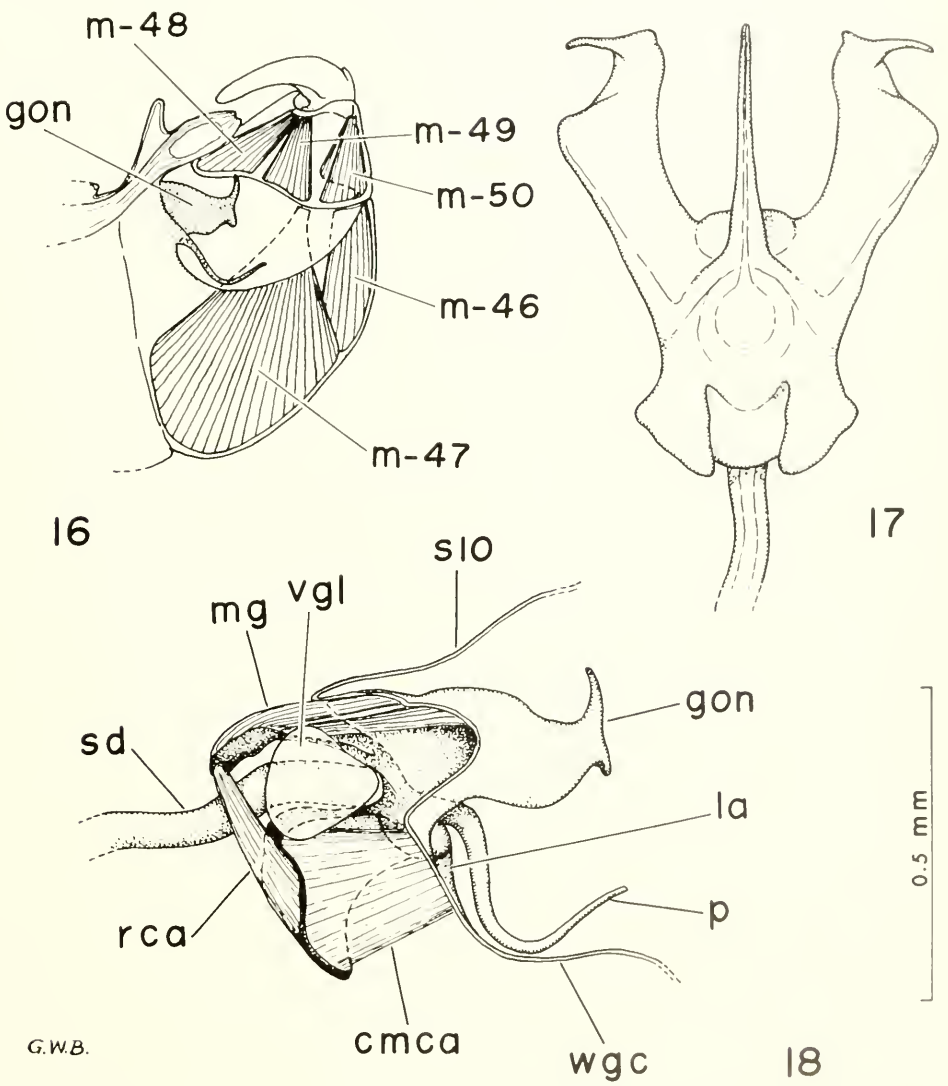
All the leg segments are sparsely covered with long, usually stout hairs or setae (Fig. 12, a), which on the femora and tibiae of most species are set in a variable number (e.g., 6-11 on the femora) of more or less definite but irregularly spaced, longitudinal rows. In most species the setae of the femora and tibiae are extremely attenuate and curved back at the tips (Fig. 12), and those on the dorsal surface are longer and less depressed than those on the ventral parts of the leg. In addition to these stout setae, there are slender, erect hairs (Fig. 12, b) occurring sparsely in a dorsal, ventral and two lateral rows, in which rows there also occur short, slender, strongly-decurved hairs (Fig. 12, c). The setae are long and thin in *C. valga* and the rows usually indistinct, giving this species a somewhat fuzzy appearance at low magnifications. In *C. stoneana,* likewise, the setae do not occur in distinct longitudinal rows. This species is different from the others in having the leg setae, most conspicuously those of femora and tibiae, short, each arising from a low, rounded papilla.

On the anterodorsal surface of each trochanter there is an oval, slightly elevated pad beset with fine, stiff hairs, each arising from a tiny pit. And on the ventral side of the femur, near the base, there is a rugose area containing shallow, oval depressions. These two modifications of leg segments are probably sensory.

Abdomen.—In both males and females the abdomen is largely membranous, with extensive pleural areas and with the sclerites widely separated. This is most noticeable in distended specimens such as those preserved in alcohol, but even when the insects are dried the pleural membrane bulges outward in conspicuous folds. When specimens are preserved dried, also, the abdomen contracts or telescopes so much that entire segments are likely to become concealed. Thus, Doane (1900: 189) described the female of *Chionea nivicola* as having a total of only six abdominal segments; and the number of segments before the enlarged ninth, or genital, segment in the male, accurately shown for *C. valga* by J. H. Emerton (Johnson, 1907: 43), was illustrated as seven in *C. alpina* by Marchand (1917: Fig. 1) and as six in *C. gracilis* and only four in *C. primitiva* by Alexander (1917: Figs. 1, 2). There is little modification of the first eight abdominal segments in the male or of the first seven in the female, except that the first sternum is very short (that is, a slender, transverse sclerite somewhat expanded at its ends) and the second sternum usually has a small, wedge-shaped sternite anteriorly at each side (Fig. 7). Spiracles occur on the first seven segments in both sexes. The terga and sterna are sparsely hairy and the terga especially may show an indistinct pattern of coloration (Fig. 1). The membrane appears smooth at magnifications up to 120×, but closer examination with the compound microscope reveals tiny subcircular patches of a few hairs each. Embedded in the membrane and distributed along the edges of the terga and sterna and in thin transverse lines dorsally between the terga and ventrally between the sterna (Figs. 6, 7) are a number of minute smooth, oblong, sclerites of various dimensions; these serve for muscle attachment, as will be discussed later. It seems appropriate to refer to these as microtergites and microsternites.

Modification of the abdomen in the male begins with the very strongly sclerotized ninth segment, the tergum and sternum of which are solidly fused into a continuous ring, which is prolonged ventrally beneath the thick basistyles (Fig. 6). Seen from above, the posterior margin of the ninth tergum appears either broadly and evenly emarginate (as in *C. valga*) or entire (as in *scita*), or it may be more distinctly, even narrowly, indented with blunt or

projecting setiferous lobes at either side of the emargination (as in *albertensis*). The basistyles are separated from the sternum and are freely movable. Completely sclerotized mesally as well as laterally, the basistyles have roughly the shape of truncate cones but are somewhat curved inwardly at their apices. They bear long setae on their outer surfaces but shorter, more slender hairs on the mesal surfaces. On the inner posteroventral surface of each there is a thickened, blunt protuberance (Figs. 145, 146, 165, 175), often comprising two rounded lobes, densely covered with short,



Figs. 16-18, *Chionea alexandriana*, details of male genital structures. 16, composite longitudinal section through ninth abdominal segment to show musculature of basistyle and dististyle: gon—gonapophysis, m—muscle (see text for origins, insertions and actions of numbered muscles). 17, gonapophyses, vesica, penis and anterior seminal duct, dorsal aspect. 18, genital structures, to show musculature: cmca—compressor muscle of compressor apodeme, gon—right gonapophysis, la—lateral apodeme, mg—muscle of gonapophysis, p—penis, rca—retractor muscle of compressor apodeme, sd—seminal duct, s10—tenth sternum (membranous anal segment), vgl—vesicular gland, wgc—wall of genital chamber (membranous). Scale: Fig. 18.

fine hairs. Each basistyle bears a single elongate, rigidly sclerotized dististyle, rather finger-like in general aspect. It is thickest and irregularly shaped at the base and usually more or less evenly curved and somewhat tapered toward the apex. There is a prominent, sometimes darkened, posteromesal tooth near the base (Figs. 155, 184), also a very small, inconspicuous, anteromesal tooth and an additional blackened ventral tooth of variable shape and size, most conspicuous in larger males, often rudimentary in smaller males and apparently invariably absent in certain species. The dististyle is sparsely covered with setae along its outer (dorsal) surface but is bare on its inner curvature, except for a small patch of stiff hairs near the base.

Ordinarily the gonapophyses (cf. Crampton, 1942: 92) are not easy to see because they are concealed from below and behind by the ninth sternum and basistyles and from above by the membranous tenth segment (Fig. 16). However, with the tip of a needle the tenth segment may, in a softened specimen, be pushed forward beneath the ninth, exposing the gonapophyses. Since this is the way they are most readily seen, I have illustrated the dorsal aspect for each species in the taxonomic treatment which follows. The gonapophyses are hardened and may be blade-like or hooked at the tip, as briefly discussed earlier, but they are hollow basally, where they are immovably fused to the sclerotized wall of the genital chamber and more flexibly attached laterally to the underside of the ninth tergum where it adjoins the basistyles (Fig. 18). These projections in *Chionea* could be described morphologically as parameres and probably are not homologous with the gonapophyses of some other tipulids, *Dolichopeza* for example (Byers, 1961*b*: 688); however, I am retaining the term because of its past use in taxonomy and because the structures seem to conform to a general definition of gonapophyses.

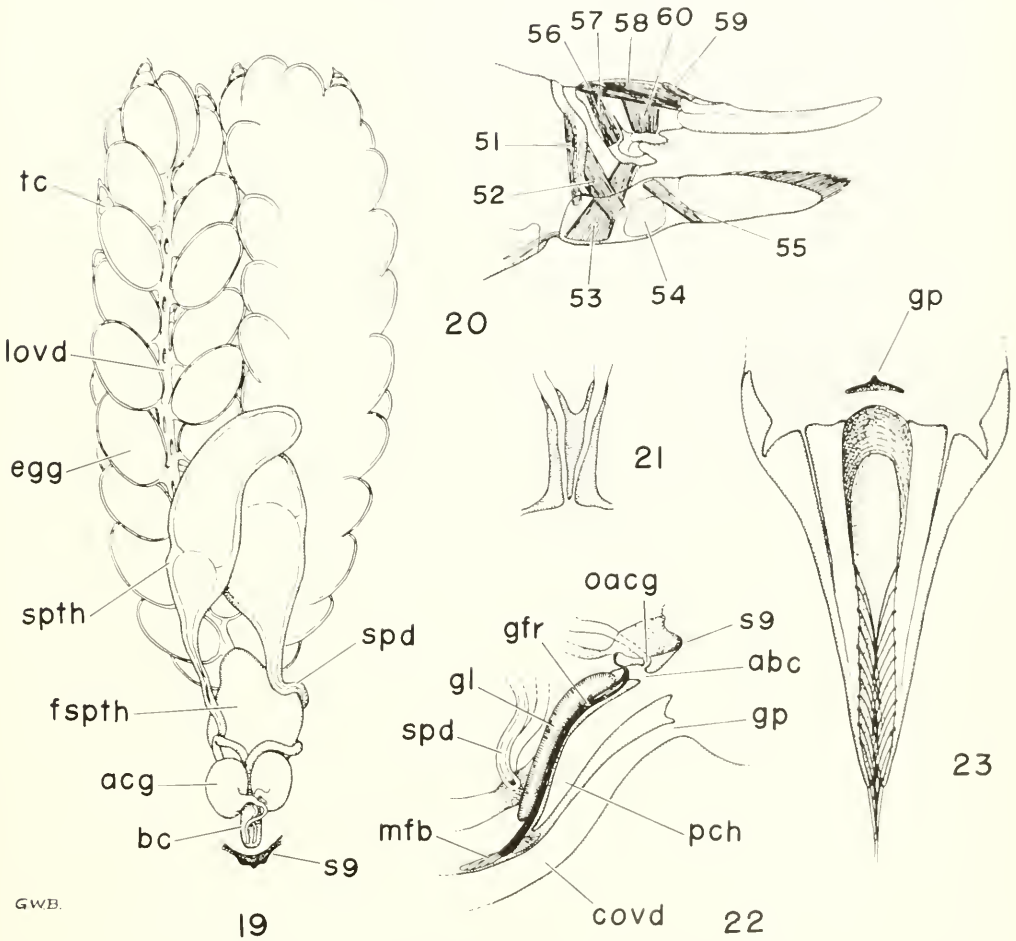
Emerging through the anterior wall of the genital chamber between the bases of the gonapophyses, the penis, a short, nonextensible intromittent organ, curves downward to the floor of the genital chamber and then upward again (Fig. 18). In most species the distal end of the penis is unmodified, but in *C. albertensis* it is produced into two sharp points and in *C. valga* and *C. obtusa* into two sinuate flagella; in *C. scita* there is a spoon-shaped extension at the tip.

Behind the ninth segment, or hypopygium, there is only the membranous tenth, or anal, segment. It could be argued that morphologically this must be the fused tenth and eleventh segments, but in *Chionea* there is no indication of a division into two parts. In some species the sides of this segment are pigmented and lightly sclerotized (Fig. 6).

In the female the eighth and succeeding abdominal segments are modified for copulation and oviposition. Elsewhere (Byers, 1961*b*: 690-692), I have compared the tipulid ovipositor in some detail with that of a typical pterygote insect, and since the female terminalia in *Chionea* do not differ greatly from those of a tipuline crane fly, the comparison need not be repeated here. Unlike the terga before it, the eighth tergum extends completely across the pleuron, and although it is not fused with the eighth sternum the two are joined by a strong, flexible attachment. In all species the eighth tergum is very short, about half the length of the seventh in some species (Figs. 112, 147) and reduced to a slender, transverse strap (Fig. 7) in others. It is bare except for one or a few hairs at each side. The sternum, in contrast, is not only longer than any other but is prolonged backward as two egg guides, the hypovalves, or ventral valves, of the ovipositor (Fig. 7). There is a deep cleft at each side between the sternum proper and the hypovalves, and in this region the connection is membranous, allowing vertical move-

ment of the valves. Numerous long, stout, yellowish setae are deeply set into the thickened, sclerotized apical and infolded dorsal margins (Fig. 23). These appear to be immovable or only slightly movable setae and are presumed to be instrumental in the placement of eggs.

In the membrane between the eighth and ninth terga, at about the level of the lower edge of the ninth tergum on each side, there is a small, sclerotized spot about the size of a spiracle. These small sclerites are most prominent in species of the *alexandriana* group. They are larger and more elongate dorso-ventrally in *albertensis* and *scita* but inconspicuous in these species be-



FIGS. 19-22, *Chionea alexandriana*, 23, *Chionea nivicola*, details of female reproductive system. 19, internal reproductive organs, dorsal aspect; acg—accessory gland, bc—bursa copulatrix, egg—egg or ovum, fspth—functional spermatheca (anterior end of bursa), lovd—lateral oviduct (some ovarioles cut away, their points of attachment indicated by elongate ovals on drawing), spd—spermathecal duct, spth—spermatheca (inner lines represent outlines of masses of sperm), s9—ninth abdominal sternum, tc—trophocyte. 20, composite longitudinal section to show musculature of ovipositor; numbers indicate muscles (see text for origins, insertions and actions of numbered muscles; note ventral end of m-52 cut away to reveal cross-section of m-54). 21, bases of ducts of accessory glands enclosed in common covering. 22, sagittal section of posterior ends of bursa copulatrix and oviduct; abc—aperture of bursa copulatrix, covd—common or median oviduct, gfr—genital furca, gl—gland (cf. Fig. 44), gp—gonopore, mfb—muscles of furcal base, oacg—opening of accessory glands, pch—pouch between genital furca and upper wall of oviduct, spd—spermathecal duct, s9—ninth sternum. 23, hypovalves of eighth abdominal sternum, dorsal aspect; gp—gonopore.

cause of their pale yellowish color, and they appear to be absent in species of the *valga* group. I have not determined their significance.

Segments behind the eighth are reduced in diameter, their terga occurring above the elongate eighth sternum and their sterna partially or completely concealed. The ninth tergum is broadly fused dorsally with the tenth, from which it is separated laterally by a deep, narrow incision, below which the lateral extensions turn backward and inward to join the ninth sternum. The connection to the ninth sternum looks tenuous but is tough and not easily severed with dissecting needles. As used here the term ninth sternum means the sclerotized portion that is more darkly colored than surrounding membranous areas and is not cleared by potassium hydroxide in specimens prepared for mounting on microscope slides. Of course, this may not constitute the entire morphological ninth sternum, the limits of which have not been determined. This sclerotized portion may comprise simply two convergent bands, but more often a median plate, of variable shape depending on the species, is formed.

Between the ninth sternum and the upper surface of the eighth is the genital chamber into which the separate divisions of the reproductive system open (Fig. 22). Embedded in the membranous wall of the chamber just beneath the ninth sternum is the genital furca (see Byers, 1961*b*: 693), the arms of which join the ninth sternum and the base of which is attached to the roof of the common oviduct. Situated medially below the ninth sternum and bracketed by the arms of the furca is the aperture of the bursa copulatrix. The median or common oviduct rises sharply from the floor of the eighth sternum so that the gonopore lies not far below the opening to the bursa (Fig. 22). A deep pouch is formed between the furca and the lightly sclerotized upper wall of the oviduct.

Less modified than the ninth, the tenth or pygidial segment consists of a well sclerotized, saddle-like tergum and a weakly sclerotized, sparsely hairy sternum, above which is the anal opening. Flexibly joined to the posterior end of the tenth tergum, supposedly arising between the tenth and eleventh, are the cerci (Fig. 7) which typically are elongate, sabre-shaped and strongly sclerotized, being especially thickened along their dorsal edges. A trace of sclerotization between the cercal bases may represent the eleventh segment. The cerci are often referred to as the dorsal or upper valves of the ovipositor. Scattered over their outer surfaces but particularly concentrated at the tips are a number of microscopic pegs set in circular bases. Although their histology has not been examined, these are presumed to be sensilla related to the detection of appropriate sites for oviposition.

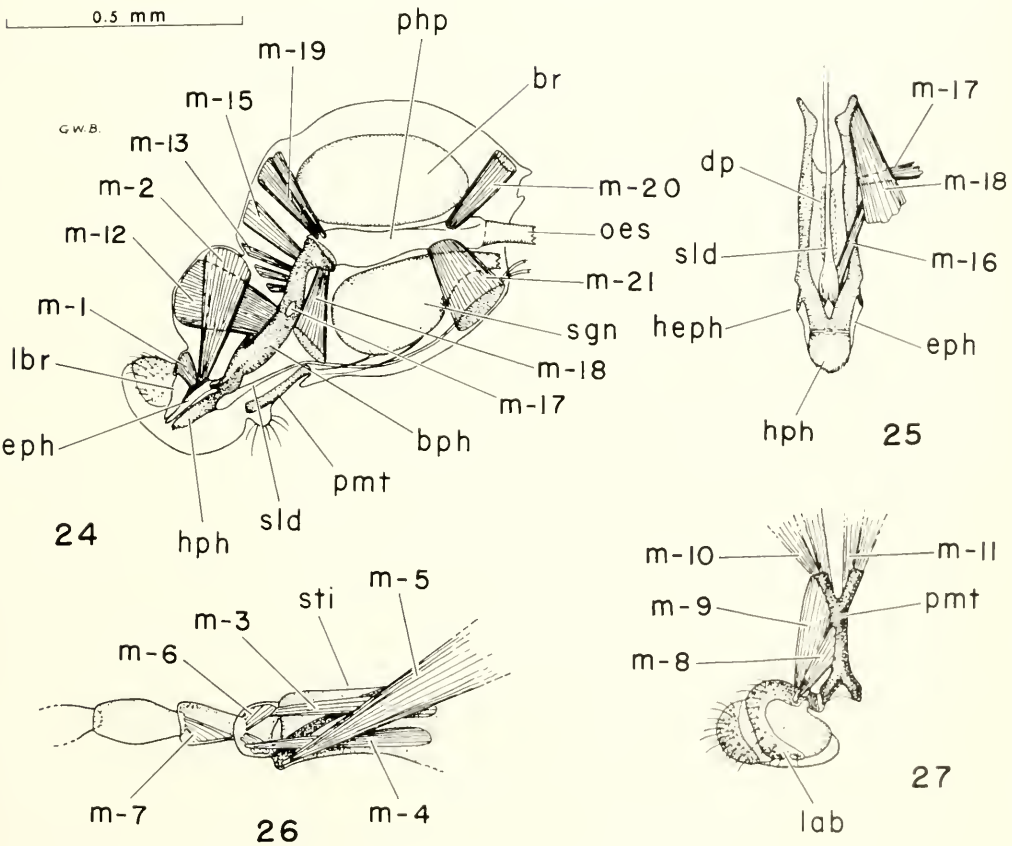
ADULTS—INTERNAL MORPHOLOGY

Head.—Within the head, the most conspicuous structure is a large, compact mass of nervous tissue made up of the brain and suboesophageal ganglion (Figs. 24, 30). Seen from above (Fig. 29), the brain is clearly divided into right and left lobes, which appear to belong to the protocerebrum. These are curved downward at the sides (Fig. 30), concealing the poorly defined deutocerebral lobes from which the antennal nerves extend directly into the bases of the antennae. The optic lobes (Fig. 29) are remarkably small in relation to the large protocerebrum, probably due to the reduced number of ommatidia in the compound eye and hence fewer entering nerve fibers. Only a slight constriction at each side between the brain and the large suboesophageal ganglion indicates the position of the circumoesophageal connectives, and the ganglion and brain together make up an essentially continuous, broad, thick ring through which the pharynx passes (Fig. 30). From the lower surface of the suboesophageal ganglion,

nerves were traced to the maxillary palps and to the labella. No nerves other than these and the antennal nerves were examined in any detail.

The pumping apparatus of the anterior digestive tube, together with its musculature, occupies most of the remaining space within the head. From the hypopharynx the digestive tube proceeds upward in the form of the rigid basipharynx, the sides of which are strongly sclerotized (Fig. 24). This joins the less strongly sclerotized pharyngeal pump, which is roughly triangular in cross-section (Fig. 30), concealed for most of its length by the brain and suboesophageal ganglion, and enlarged at the ends, where the muscles that operate it attach. From a membranous pouch at the junction of basipharynx and hypopharynx, where it enters the preoral cavity, the common salivary duct extends back along the ventral side of the head capsule, dividing just before the neck, one branch passing up along each side of the nerve cord as it comes off the suboesophageal ganglion (Fig. 24).

For ease of reference from text to figures, I have numbered the major muscles



FIGS. 24-27, *Chionea alexandriana,* details of head and mouthparts. 24, internal structures of head, parasagittal section; bph—basipharynx, br—brain, eph—epipharynx, hph—hypopharynx, lbr—labrum, m—muscle (see text for origins, insertions and actions of numbered muscles), oes—oesophagus, php—pharyngeal pump, pmt—prementum, sgn—suboesophageal ganglion, sld—salivary duct. 25, basipharynx and hypopharynx, ventral aspect; dp—dorsal plate in membranous wall, for attachment of muscle 12, eph—epipharynx, heph—hinge of epipharynx, hph—hypopharnyx, m—muscle, sld—salivary duct. 26, maxilla and basal segments of maxillary palp, anterior (inner) aspect; m—muscle, sti—stipes. 27, labium, in part, anterior aspect; lab—labial palp (labellar lobe), m—muscle, pmt—prementum (prementum and mentum?). Scale: Fig. 24.

found in the head capsule and mouthparts and have listed them below by number, giving for each the origin, insertion and presumed action. Each numbered muscle or group of muscles is paired except where otherwise indicated.

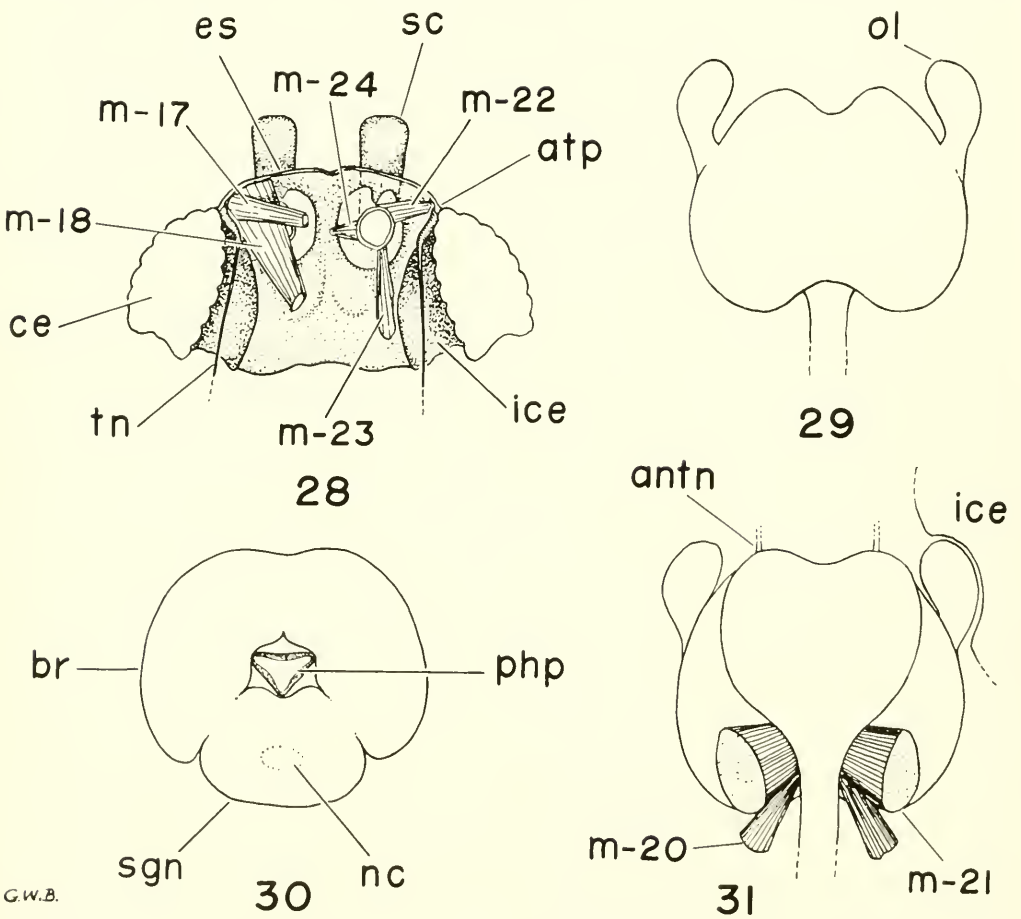
1. labrum to oblong sclerotized plate in the thin, almost transparent epipharynx; elevates epipharynx, distending cibarium (Fig. 24).

2. posterior clypeus alongside midline to end of oblong sclerotized plate of epipharynx; elevates epipharynx and draws it backward.

3-4. stipes (or sclerite in which it is embedded) to first segment of maxillary palp; respectively elevate and depress palp (Fig. 26).

5. head capsule below eye to distal end of stipes; adducts palp. (Abduction may be brought about by resilience of the stipes and associated sclerite.)

6. dorsal and ventral inner surfaces of first palpal segment to proximal rim



FIGS. 28-31, *Chionea alexandriana*, details of head and anterior central nervous system. 28, internal (posteroventral) aspect of frons; atp—anterior tentorial pit, ce—compound eye, es—epistomal suture, ice—inner surface of compound eye, m—muscle (see text for origins, insertions and actions of numbered muscles), sc—scape, tn—tentorium. 29, brain and anterior nerve cord, dorsal aspect; ol—optic lobe of brain. 30, brain (br) and suboesophageal ganglion (sgn), posterior aspect; nc—position of attachment of nerve cord, php—pharyngeal pump, in cross-section. 31, suboesophageal ganglion and brain, ventral aspect; antn—antennal or antennary nerve; ice—inner surface of compound eye, m—muscle.

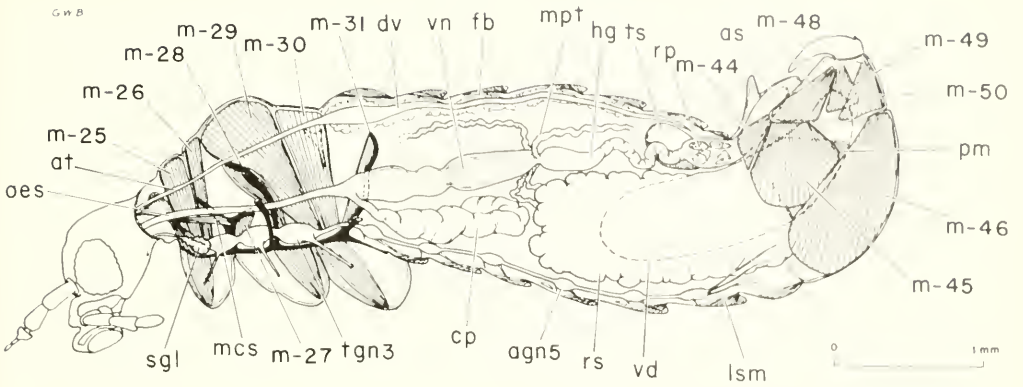


FIG. 32, *Chionea alexandriana,* internal structures of thorax and abdomen of adult male, composite of parasagittal sections; agn5—abdominal ganglion of fifth segment, as—anal (tenth) segment, at—aorta, cp—crop, dv—dorsal vessel (heart), fb—fat body (portion along dorsal vessel), hg—hind gut, or intestine, lsm—longitudinal sternal muscle, m—muscle (see text for origins, insertions and actions of numbered muscles; m-28 originates on mesothoracic furca; m-31 originates on metathoracic furca), mpt—malpighian tubule, oes—oesophagus, pm—pleural muscle from ninth sternum to ninth tergum (largely concealed by m-45; its outline indicated by dotted line), rp—rectal papilla, rs—reproductive system (enclosed in irregular portions of fat body; see vd), sgl—salivary gland, tgn3—thoracic ganglion of metathorax (fused with first abdominal ganglion), ts—testis, vd—vas deferens (position indicated by dashed line), vn—ventriculus.

of second segment; elevate and depress second segment.

7. side of second palpal segment to proximal rim of third segment; elevates third segment; no antagonistic muscle found.

8. mid-length of prementum to anterobasal surfaces of first segment of labellum; elevates labellum (labial palp) and rotates it on its basal attachment (Fig. 27).

9. proximal arm of prementum to posterobasal surface of first labellar segment; elevates labellum.

10-11. head capsule below and behind eyes to apex of proximal arm of prementum; elevates entire labium, drawing it into the head capsule.

12. anterior clypeus to elongate, sclerotized plate in semi-membranous dorsal wall of basipharynx; dilates basipharynx (Fig. 24).

13-14. head capsule along epistomal suture to dorsolateral edge of basipharynx (14: a pair of closely associated, small muscles); elevate proximal end of basipharynx.

15. frons near mid-line to semi-membranous roof of basipharynx; dilates basipharynx.

16. edge of head capsule near base of rostrum to basipharynx just above attachment of salivary duct; retracts basipharynx (Fig. 25).

17. edge of head capsule near anterior tentorial pit to side of basipharynx; moves basipharynx laterally, probably for maintenance of position and not for dilation (Figs. 24, 25, 28).

18. edge of head capsule below and in front of eye to proximal end of basipharynx; extends basipharynx (Fig. 25).

19. anterolateral vertex to anterior end of pharyngeal pump (two closely adjacent muscles); elevate end of pump and probably dilate it (Fig. 24).

20. lateral occipital region to posterodorsal surface of pharyngeal pump; a major dilator of pharyngeal pump (Figs. 24, 31).

21. posterior genal area to posteroventral surface of pharyngeal pump; a major dilator of pharyngeal pump (Figs. 24, 31).

The tentorium comprises two widely separated portions, very simple in structure (Fig. 28, tn), each a little thickened and irregularly bent anteriorly (probably the tentorial pit), then straight, extremely thin and thread-like to the posterior pit. There appear to be no muscle attachments along most of the length of the tentorium, but two small muscles (one to the scape and one to the basipharynx) originate on or very near the anteriormost end.

Three small, inconspicuously placed muscles (Fig. 28) move the antenna, all lying rather flat against the surface of the head capsule. Their origins, insertions and actions are as follows:

22. edge of head capsule, apparently on anteriormost tentorium, to anterolateral base of scape; moves antenna downward and sideward.

23. frons alongside inner margin of eye to posterior (upper) basal rim of scape; elevates antenna.

24. thin median bridge of frons between antennal sockets to mesal base of scape; adducts antenna.

Within the antenna the only muscles are those of the pedicel, originating respectively on the upper and lower surfaces of the scape, inserting on the basal rim of the pedicel and acting as elevator and depressor of the antenna.

The cervical sclerite has two small muscles inserted on its posteroventral edge, one from the anterior prosternum and the second from near the branch of the prosternal apophysis (Fig. 32, mcs).

Thorax.—It is hardly surprising that the indirect flight muscles, so conspicuous in the thorax of most Tipulidae, are not found in *Chionea*. The resulting space, however, both volume and surface for muscle attachment, has been largely taken up by the increased development of the muscles of the legs. To discuss the musculature it is first necessary to describe briefly the internal skeletal structure. This consists of three pairs of elongate sternal apophyses and the corresponding pairs of smaller pleural apophyses, as well as a low, median ventral keel running through all three segments. The prothoracic sternal apophyses (Figs. 13, 32) are widely separated basally. Each has an anterior arm, extending upward and a little outward to fuse with the very small pleural apophysis a short distance above the coxal process, and a slightly shorter posterior arm, which extends backward into the mesothorax. The mesosternal apophyses (Figs. 14, 32, as origin of m-28) are joined at the base, arising from the mid-ventral keel; they are unbranched, each with a flattened tip that has a muscular attachment to the blade-like, downwardly hooked pleural apophysis just below the vestigial wing. The metasternal apophyses (Fig. 15) are likewise joined basally, diverging abruptly and bent backward into the first abdominal segment (Fig. 32), the apophyseal arm having no connection to the pleural apophysis. Matsuda (1970: 319) noted that wide separation of the coxae does not greatly alter the exoskeletal structure from that seen in other Tipulidae.

Only the major muscles were examined in any detail. Again, these are numbered to facilitate reference from text to the illustration (Fig. 32).

25-26. pronotum and anterior mesonotum to ventral basal rim of trochanter of front leg; depress front trochanter, probably also femur.

27. posterior branch of prosternal apophysis to posterior edge of coxal base; remotor of front coxa. Note: promotor originates on mid-ventral keel and inserts on lower anterior edge of coxal base.

28. mesopleural apophysis and upper mesosternal apophysis to ventral basal rim of trochanter of middle leg; apparently one muscle from either side of the joined apophyses, both depressors

of the trochanter and probably also of the femur. Note: promotor of middle coxa originates on mid-ventral keel, its remotor on lower part of mesosternal apophysis.

29-30. posterolateral mesonotum and metanotum to ventral basal rim of trochanter of hind leg; depress hind trochanter, probably also femur.

31. apical half of metasternal apophysis to lower posterior edge of hind coxa; remotor of coxa. Note: promotor originates on mid-ventral keel.

A few of the lesser muscles deserve some comment. For example, there is a thin strand from the metapleural apophysis to the anterodorsal rim of the hind coxa. At the base of the haltere, seen from within (Fig. 35), there is a small, fan-shaped muscle serving to depress the haltere, which seems to be elevated by the resilience of the attachment. The wing vestiges appear to have no muscles at all.

Since the musculature of all legs is essentially the same, that of the hind leg will serve as an example. Figure 34 indicates the articulation and musculature of the right hind leg, seen from behind. The coxa is vertically hinged, the trochanter horizontally. Although the femur is scarcely movable on the trochanter, it does have a hinge-line from the anteroventral to posterodorsal rim of the recess in the trochanter (Fig. 37). Both the femoro-tibial and tibio-tarsal joints are dicondylic and horizontal, or nearly so, but thereafter the joints within the tarsus are monocondylic and not affected by direct muscles. Figure 34 shows the large depressors of the trochanter (m-29, m-30) entering from the thoracic cavity, passing through the coxa, and inserted on a long, paddle-shaped tendon attached to the ventral edge of the trochanter. The coxal remotor (m-31) has also been described earlier. Other muscles of the hind leg are (Fig. 34):

32. mid-ventral keel of metathorax to anteroventral edge of coxal base; promotor of coxa.

33. dorsal surface of coxa to spatulate tendon attached to anterodorsal edge of base of trochanter; elevates trochanter.

34. posterodorsal surface of coxa to small, disk-shaped tendon just above posterior condyle of trochanter; elevates trochanter.

35. posteroventral surface of coxa to ventral rim of base of trochanter; depresses trochanter.

36. anteroventral surface of coxa to

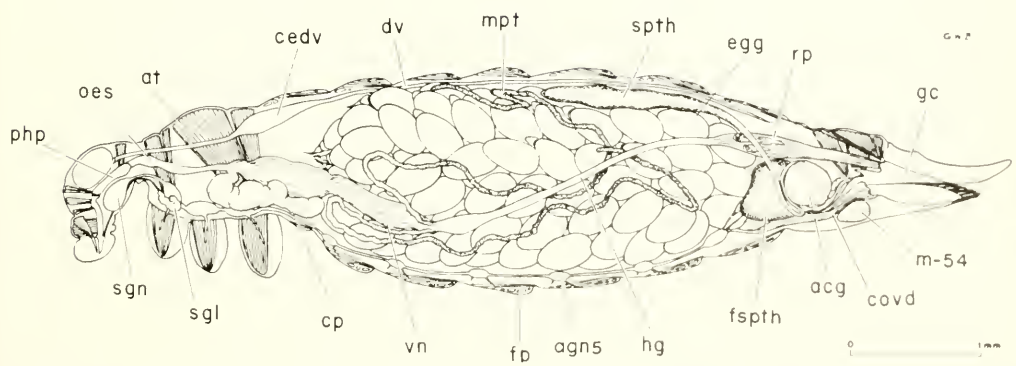


Fig. 33, *Chionea alexandriana,* internal structures of adult female, composite of parasagittal sections; acg—accessory gland, at—aorta, cedv—cardiac enlargement of dorsal vessel, covd—common or median oviduct, cp—crop, dv—dorsal vessel, fp—fat pad, fspth—functional spermatheca (anterior end of bursa copulatrix), gc—genital chamber, agn5—abdominal ganglion of fifth segment, hg—hind gut or intestine, mpt—malpighian tubule, m-54—transverse muscle of eighth sternum, oes—oesophagus, php—pharyngeal pump, rp—rectal papilla, sgl—salivary gland, sgn—suboesophageal ganglion, spth—spermatheca, vn—ventriculus.

ventral base of trochanter; depresses trochanter.

37. posterodorsal, posterior and posteroventral surfaces of trochanter to posterior base of femur just beyond hinge-line; moves femur slightly backward, very slightly upward.

38. dorsal surface of trochanter near base to posterodorsal base of femur just beyond hinge-line; moves femur very slightly backward and upward. Note: Snodgrass (1935: 197) says that when the femur is movable on the trochanter the action is production-reduction of the femur although only a reductor muscle is present. This muscle (m-38) appears separate, but it could be regarded as essentially continuous with the larger femoral muscle (m-37).

39. ventral and posterior surfaces of femur for nearly the entire length via a long tendon to ventral side of tibia near its proximal end; depresses tibia.

40. dorsal and anterior surfaces of femur in distal two-thirds or more via a long tendon to proximal head of tibia; elevates tibia.

41. dorsal surface of tibia, proximally, around posterior to ventral surface, distally, via long tendon to ventral base of basitarsus; groups of fibers spaced apart in distal portion of muscle; depresses tarsus.

42. dorsal and anterodorsal surfaces of distal half of tibia via long tendon to dorsal base of basitarsus; structure as in tarsal depressor (m-41); elevates tarsus.

43. ventral surface of tibia near proximal end to long unguitractor apodeme, which runs from unguitractor plate of pretarsus through tarsus, tibia and most of femur; retractor of pretarsal claws. This long apodeme has other, smaller muscles, but these were not observed in detail.

Origin in the mesothorax of large depressors of the prothoracic and metathoracic trochanters (m-26, m-29 in Figs. 32, 34) is unusual and needs some explanation. While the depressors of the hind trochanter in most insects originate in the metathorax, there has been such an increase in size in the posterior metathoracic muscle (m-30) in *Chionea* (and particularly in males) that the anterior group of fibers has been displaced forward into the space left vacant by the loss of the mesothoracic indirect flight muscles. Similarly, depressor m-25 has such an extensive origin on the pronotum that the posterior depressor of the prothoracic trochanter is displaced onto the anterior mesonotum, before the pseudosutural depression. This explanation, of course, avoids the question of why the depressors of the mesothoracic trochanter (m-28) do not originate on the mesonotum but on apophyses instead. A possible answer to this—or more specifically to why the muscles of the fore and hind trochanters should be so large as to crowd into the mesothorax—may be found in the insects' behavior. But to begin with it should be pointed out that the femoral muscles (i.e., those within the trochanter) are very small and that the joint between the trochanter and femur allows only slight movement. It may therefore be reasonably supposed that these large muscles not only depress the trochanter but serve as the primary movers of the femur as well. Accordingly, they and their counterparts in the mesothorax largely support the body during walking and are also used in a peculiar raising and lowering of the body when the insect is in a resting position (Fig. 50). In mating, the male often assumes a stance (Fig. 49) that throws nearly all his weight onto the hind legs and still requires a certain amount of locomotion. This may account for the greater development of the depressor muscles of the hind trochanter in males.

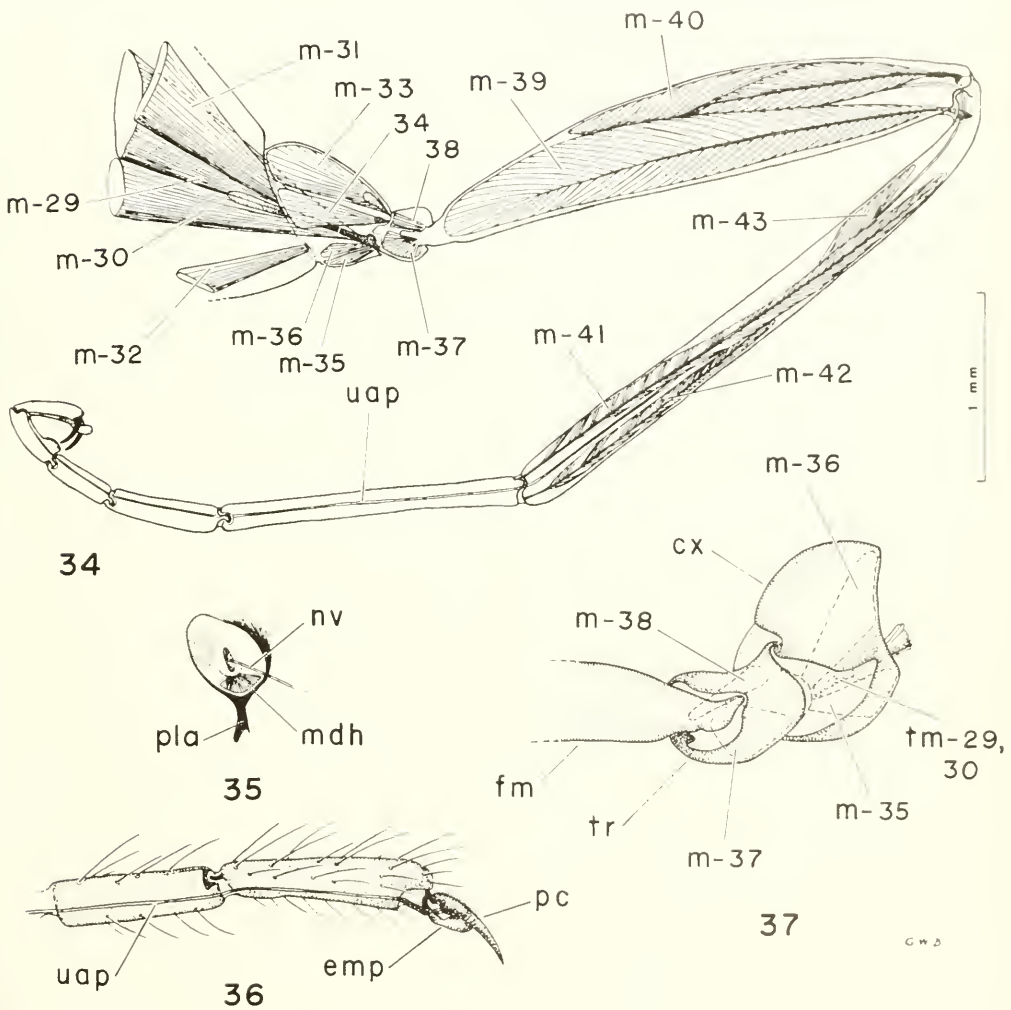
Need for support in walking would

also explain the large depressors of the tibia and tarsus. Most of the levator muscles, in contrast, probably are not often under much tension and hence are small. The levator of the hind tibia (Fig. 34, m-40), however, is relatively large, which explains the insect's ability to leap, an activity occasionally observed.

For the sake of continuity of description, the thoracic portions of the nervous, digestive, circulatory and respiratory systems will be dealt with below under the heading Abdomen.

Abdomen.—Contained within the abdomen are the entire reproductive system, most of the alimentary tract and dorsal vessel, and the greater part of the length of the central nervous system.

The body wall in the pregenital segments is rather simply constructed. In the



Figs. 34, 35, 37, *Chionea alexandriana*. 36, *Chionea lyrata*. thoracic appendages. 34, musculature of right hind leg, male, posterior aspect: m—muscle (see text for origins, insertions and actions of numbered muscles), uap—unguitractor apodeme. 35, interior aspect of base of left haltere: mdh—muscle, depressor of haltere, nv—nerve to interior of haltere, pla—pleural apophysis. 36, apical two tarsomeres and pretarsus: emp—empodium, uap—unguitractor apodeme, pc—pretarsal claw or unguis, 37, base of left middle leg, male, ventral aspect: cx—coxa, fm—femur, m—muscle (positions indicated by dashed lines; see text for origins, insertions and actions of numbered muscles), tm—tendon of muscles 29, 30, tr—trochanter. Scale: Fig. 34 only.

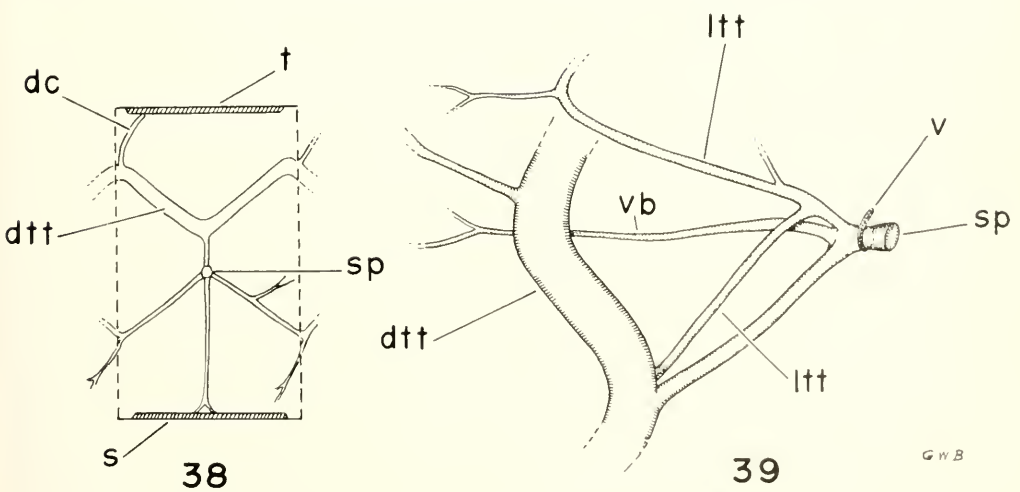
pleural region there are thin, flat, separated strands of muscle oriented vertically and attached to the small, oblong sclerites described earlier, which are assumed to be fragments of the terga and sterna. The sterna are linked by two sets of longitudinal muscle fibers: sparse and very thin inner strands extending from one antecosta to the next and shorter, more dense outer bands (Fig. 32, lsm) originating on the antecosta or nearby sternum and inserting on the next posterior transverse row of microsternites. These sclerites thus may represent the fragmented anterior margin of the acrosternite. Between terga the muscular connection is in general the same, but while the longitudinal ribbons of muscle lie side by side in a continuous sheet across the breadth of the sternum they are interrupted medially beneath the terga to make room for the heart, or dorsal vessel. Interspersed among the longitudinal muscle strands, wedged between them and the exoskeleton, and in general clustered against the body wall are numerous small, pad-like particles of fat tissue (Fig. 33, fp). These are most abundantly associated with the dorsal abdominal wall, and very few are found among the pleural muscles. In the female there is little other fat within the body except for a few short cords among the posterior reproductive organs. Males, however, usually contain large amounts of additional fat, both in the form of short, serpentine cords dispersed among all the abdominal viscera and as more extensive masses particularly in the anterodorsal part of the abdomen and along the dorsal vessel (Fig. 32, fb).

The dorsal vessel is thin-walled and (at least in specimens preserved in alcohol) flattened against the terga. Although the chambers in the heart or cardiac portion of the vessel are not well defined, there is a distinct widening of the vessel in the first two abdominal segments. From this cardiac enlargement the aorta extends more or less directly downward and forward to enter the head directly above the oesophagus.

From the suboesophageal ganglion the apparently undivided ventral nerve cord arches into the thorax to join the first thoracic ganglion, lying between the prosternal apophyses. The mesothoracic ganglion follows close behind the first and is separated from the metathoracic ganglion by a clearly double nerve cord, which is suspended in the fork of the mesosternal apophyses. Each thoracic ganglion gives off a pair of major nerves into the adjacent legs, as well as some lesser branches. There are six smaller, abdominal ganglia (agn), the first lying usually in the anterior second segment, the last in the seventh segment, and the others spaced approximately as shown in Figures 32 or 33. Each of the first five gives rise to a posterior pair of major nerves and an anterior pair of very slender nerves, all extending laterally and branching onto the body wall. From the back of the metathoracic ganglion, a pair of nerves resembling the larger ones from an abdominal ganglion arises medioventrally and extends into the first abdominal segment, suggesting fusion of the first abdominal and last thoracic ganglia. The terminal abdominal ganglion, which varies from two to three times as broad as the others, gives rise not only to slender anterior nerves but two pairs of larger nerves extending backward to the muscles of the genitalia, again suggesting the fusion of two or possibly three ganglia. In females (Fig. 33) the larger nerves from the last abdominal ganglion are of approximately equal diameter, but in males (Fig. 32) the first or outer pair are about twice the diameter of the second pair and lead into the basistyles. None of the nerves was traced beyond its basal portion. This description of the central nervous system is in fair agreement with that given by Brauer et al. (1854: Fig. 7) except in the structure of the brain and suboesophageal ganglion.

Extending backward through the thorax from the pharyngeal pump is the slender oesophagus, which joins the ventriculus, or mid-gut, near the anterior end of the abdomen (Fig. 32) or farther cephalad. Beneath the anterior end of the oesophagus, in the lower prothorax near the first thoracic ganglion, are the two irregularly shaped, nodular salivary glands (sgl). The ventriculus (vn) is thick-walled and muscular. It is usually somewhat constricted near its mid-length, but in various individuals other constrictions may also occur, the shape of the organ probably reflecting its physiological condition at the time of death and preservation. In a female whose abdomen is nearly filled with eggs, the ventriculus may be displaced forward and the hind-gut drawn more or less straight (Fig. 33). Just before the junction of the oesophagus and ventriculus, the crop joins the digestive tube ventrally. It is a large, membranous, rather amorphous organ, extending backward beneath the ventriculus, the posterior end often bent back cephalad. Although it is not easy to see how *Chionea* can take any food other than liquids, I have sometimes found rust-colored or greenish particles of solid material in the crop, as well as in the oesophagus. These may be precipitates, however, as they seem to have no cellular structure even at high magnifications.

Immediately behind the ventriculus, at the proctodeal valve, four Malpighian tubules (mpt) are given off, two dorsolaterally and two with their bases close together ventrally. In preserved specimens these have a faint purplish color throughout most of their length but are whitish in the basal one-fourth, which portion of the tubule is also more slender than the rest. They are subequal in length to the thorax and abdomen together and are usually intertwined among the viscera, although the apical portions may often be found lying atop the other organs, adjacent to the rectum or the dorsal vessel. The hind-gut (hg) is a fairly simple tube, enlarged only slightly at its anterior end but constricted just behind the attachments of the Malpighian tubules. Less thick-walled than the mid-gut, it may have a slightly annulated appearance due to the muscle arrangement. The rectum is situated dorsally, close beneath the seventh and suc-



FIGS. 38, 39, *Chionea alexandriana*, details of tracheal system of adult. 38, diagram of major tracheae in typical abdominal segment, left side (anterior at right), interior aspect; dc—dorsal commissure, dtt—dorsal tracheal trunk, s—sternum, sp—spiracle, t—tergum. 39, detail of tracheae adjoining an abdominal spiracle (positional relationships distorted by mounting on microscope slide); dtt—dorsal tracheal trunk, ltt—lateral tracheal trunk, sp—spiracle, v—valve (sclerotized portion only), vb—ventral branch (to sternum).

ceeding terga. It is membranous and semi-transparent, with four conical rectal papillae (rp) attached near the anterior end, their vertexes usually directed somewhat caudad. The number of these papillae has been reported as varying with sex in some nematocerous Diptera, but in *Chionea* it is four in both males and females.

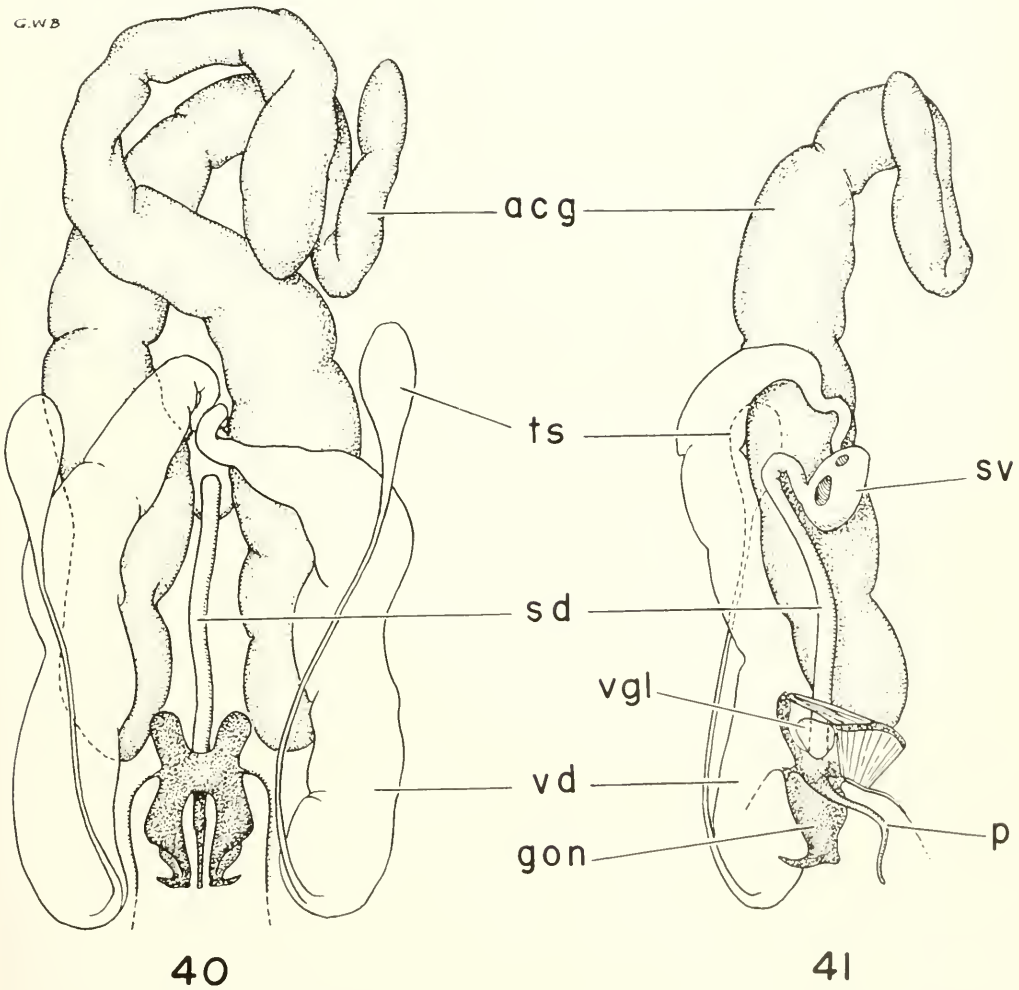
I have not studied the tracheal system in detail, but the general pattern of it can be described (Figs. 38, 39). From the thoracic spiracles (sp) a large dorsal tracheal trunk (dtt) forms on each side and extends backward to the seventh segment, where it narrows abruptly and branches into small tracheae. Dorsolateral in general position within the abdomen and closely applied to the body wall, it bends downward above each abdominal spiracle to receive an incoming trachea from the spiracle, then rises again near the intersegmental line, thus forming a zig-zag pattern. The smaller lateral tracheal trunk connects the spiracles directly but bends downward between them, giving off a branch at the lowest point (Fig. 38). There is also a ventral branch trachea, so that in all there are four major branches entering from each abdominal spiracle (Fig. 39). These give off lesser tracheae, but the detailed pattern of branching varies even from one spiracle to the next in the same individual. Commissures (dc) connect the dorsal tracheal trunks in each segment. One trachea enters each leg, that of the front leg coming rather directly from the mesothoracic spiracle, that of the hind leg from the metathoracic, and that of the middle leg apparently formed by convergence of branches from both spiracles. In the tibia the tracheal diameter is as great as in the femur, but it diminishes in the tarsus. Two pairs of tracheae enter the head, supplying air to the anterior central nervous system and the feeding apparatus. Each of the abdominal spiracles opens into a short atrium, which is lined with hairs and which may be closed internally by a C-shaped sclerotized valve (Fig. 39).

Male Reproductive System.—Brauer examined the reproductive anatomy of *Chionea araneoides* more than a hundred years ago (Brauer et al., 1854: Figs. 8, 9), but in his illustrations he omitted the sclerotized structures and misidentified the softer parts. As far as I am aware, no one has since studied the internal structure of *Chionea*, so these errors have never been corrected. In another paper (Byers, 1961*b*: 696-700) I have described the reproductive system in a tipuline crane fly, *Dolichopeza*, and although this at first appears to differ extremely from the arrangement in *Chionea* there is actually a part-for-part correspondence, except for certain muscles. Accordingly I shall make occasional comparisons of the two genera in the following discussion.

Perhaps the internal reproductive structures in *Chionea* can best be understood by proceeding from the external genitalia already described. The genital chamber (Fig. 18) is the space between the basistyles, bordered above by the venter of the tenth segment (s10) and below by the ninth sternum (wgc). Its ventral wall or floor is membranous, but the anterior wall is strongly sclerotized, except at the edges adjoining the basistyles. The dorsal portion of this sclerotic region, from just beneath the tenth segment down to the base of the penis, is formed by the fusion of the bases of the gonapophyses. In *Chionea*, the vesica, a small sclerotized bulb from which the penis originates, lies at the surface and contributes to the anterior wall of the genital chamber. Extending downward and to the sides from the vesica are its two immovable lateral apodemes (la) (cf. Byers, 1961*b*: 699). Fusion of these apodemes along the mid-line is complete in some species of *Chionea*, such as *alexandriana*, but there may be a partial separa-

tion leaving a membranous area just below the base of the penis, as in *stoneana*.

On the lateral apodemes originate the thick muscles that activate the compressor apodeme (Fig. 18, cmca). In *Dolichopeza* I called this compressor apodeme of the vesica the dorsal apodeme (Byers, 1961*b*: 699), but in that genus the vesica and all its apodemes have rotated inward, maintaining their close association with the wall of the genital chamber only by way of a thin, membranous pouch that is an extension of the chamber. The mode of action of the compressor apodeme is discussed in the reference just cited. There is at either side of the median keel of this movable apodeme a broad extension, variously curved according to the species, which serves for the insertion of the compressing muscle on one side, and of the retracting muscles that expand the vesica on the other. The latter muscles originate on a second pair of relatively fixed apodemes that diverge cephalad from the vesica in *Chionea* (but are directed posteriorly in *Dolichopeza*, on account of the rotation



Figs. 40, 41. *Chionea alexandriana*, reproductive system of male. 40, dorsal aspect. 41, right lateral aspect, organs of right side removed. Abbreviations: acg—accessory gland, gon—ponapophysis, p—penis, sd—seminal duct, sv—seminal vesicle, ts—testis, vgl—vesicular gland, vd—vas deferens.

described). These apodemes are connected by muscles (mg) to the adjacent ninth tergum and to the dorsal interior of the gonapophyses near their bases, and each receives a muscle originating at the side of the ninth tergum. The gonapophyses are only slightly movable.

Continuing inward from the vesica is the short, thick seminal duct (sd) (apparently the morphological ejaculatory duct), which leads to a small, thin-walled seminal vesicle (Fig. 41, sv), more or less median in position, in the seventh abdominal segment or thereabouts. At the sides of the vesica there are small, flattened pouches (vgl) connected around the anterior edge of the vesica to the seminal duct. While I could not find any evidence that these pouches are glandular in *Chionea,* their position suggests that they are homologous with the vesicular glands of *Dolichopeza.* There are two voluminous, dull whitish accessory glands (Figs. 40, 41, acgl), one lying at either side of the seminal vesicle and emptying into the vesicle by an extremely short tube behind the gland's midlength. From their points of attachment the accessory glands may extend posteriorly far into the ninth segment and anteriorly as far as the fourth or even the third abdominal segment. Their shape and size are extremely variable and probably fluctuate according to their physiological state and the volume of their contents. The glands may be elongate and thrown into one or two loops, or compartively short and thick, and the two in one individual are not apt to have even approximately the same shape (cf. Fig. 40). Their diameter also varies greatly, constrictions appearing here and there, so that the glands may seem to be divided into a number of compartments. No doubt this is what led Brauer to identify the anterior ends as the testes and the posterior ends as "paired appendages" of the seminal vesicle.

The vasa deferentia enter the seminal vesicle a little cephalad from the openings of the accessory glands. Although these tubes are quite slender where they join the vesicle (Fig. 41), they enlarge greatly in diameter as they curve upward over the accessory glands and remain distended for a major portion of their length. This enlarged part of the vas deferens (vd) is usually found packed with bundles of sperm, giving it a glistening, silky appearance, and probably is the functional seminal vesicle (cf. Snodgrass, 1935: 568) for, as mentioned earlier, that organ is very small. The thickened portion of the vas deferens ordinarily extends far into the ninth segment and often well into the basistyle. At its caudal extremity the vas deferens is abruptly narrowed, becoming a thread-like tube, which then reverses direction and passes back out of the ninth segment, terminating in a small, membranous sack, the testis. In his study Brauer overlooked the thin apical portions of the vasa deferentia and did not identify the sperm-laden enlargements. The relationship of parts of the male reproductive system is not easy to describe, but Figures 40 and 41 may make the above description somewhat more comprehensible.

Most of the muscles in the ninth segment are those of the genital appendages. On each side, however, there is a superficial sheet of muscle (Fig. 32, pm) connecting what might be termed the imaginary lateral margin of the ninth sternum with the equally imaginary lateral margin of the ninth tergum. Since the ninth segment is a continuous, well sclerotized ring, the function of these "pleural" muscles is not clear. Their action would be to draw the ninth tergum downward, somewhat flattening (depressing) the entire segment. The origins, insertions and actions of the other major muscles (Figs. 16, 32) are

44. anterolateral margin of ninth tergum to anterior base of basistyle; draws basistyle upward (forward).

45. anterolateral margin and pleural region of ninth segment to anterolateral base of basistyle; abducts basistyle and draws it forward.

46. ventral and lower lateral ninth segment (sternum) to posterior base of basistyle; draws basistyle downward (backward).

47. mesoventral ninth sternum to mesal margin of base of basistyle; adducts basistyle. Note: this is a large muscle, apparently responsible for the fact that preserved specimens of *Chionea* nearly always have the basistyles closed together, that is, drawn inward.

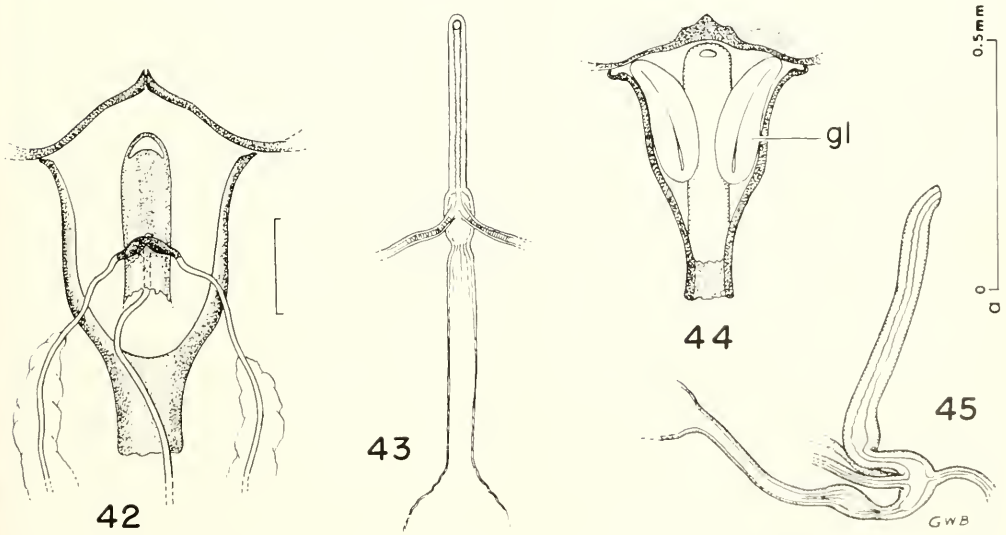
48-49. anterior and anteromesal basistyle to anterior base of dististyle; draw dististyle inward and forward, or "close" dististyles.

50. posterior basistyle to posterior base of dististyle; moves dististyle outward and backward, or "opens" dististyle.

In most respects the male reproductive system in *Chionea* is simpler than that in the Tipulinae, exemplified by *Dolichopeza*. Examples of its presumably less specialized design are the undivided dististyles, the simpler basistyles, which are not fused to the sternum, the non-rotated vesica, the straighter, shorter seminal duct and the wholly separate vasa deferentia (cf. Byers, 1961*b*: Figs. 17, 18, 27).

Female Reproductive System.—As in other crane flies I have studied, the reproductive system of females of *Chionea* consists of two separate parts: the bursa copulatrix and associated organs above, for reception and storage of sperm, and the ovaries and their ducts below. There is no internal connection between these two parts, but the external opening of each enters the poorly delimited genital chamber, as described earlier under external morphology, and to that extent they comprise a unified system.

The common or median oviduct is rather short, extending from the gonopore to just cephalad of the point where the



Figs. 42-45, comparative details of reproductive system of female. 42, *Chionea stoneana,* genital furca, ninth sternum, bursa copulatrix and spermathecal ducts, anterodorsal (interior) aspect (scale line 0.1 mm). 43, *Chionea lyrata,* bursa copulatrix and bases of spermathecal ducts, anterodorsal aspect. 44, *Chionea alexandriana,* genital furca, ninth sternum, bursa copulatrix and apparently glandular structures (gl) (cf. Fig. 22), anterodorsal (interior) aspect. 45, *Chionea nivicola,* bursa copulatrix and bases of spermathecal ducts, left lateral aspect. Scale a: Figs. 43-45.

base of the furca is anchored in the dorsal wall of the oviduct (Fig. 22, covd). Although thin-walled, it is muscular, having mostly transverse but also longitudinal muscles. The lateral oviducts (lovd) are extremely short as ducts alone, but each is continuous with the central lumen of its respective ovary, and the whole may be regarded as an elongate lateral oviduct giving off ovarioles in a radiating pattern along almost its entire length (Fig. 19). A female that has not commenced oviposition may contain as many as 200 eggs, the ovaries extending into the first abdominal segment and often even crowding into the thorax. A female of *Chionea nivicola*, for example, was found to contain 126 apparently mature eggs, of which eight were within the thorax (Fig. 48), extending even into the prothorax. The ovarioles are short, membranous and transparent, and each contains but a single egg. The older, more mature ovarioles are rounded apically, conforming more or less to the shape of the egg within, but toward the anterior end of the ovary most ovarioles contain in addition to the egg one or two smaller clusters of trophocytes, so that they are tapered at the apex (Fig. 19). In some other tipulids I have dissected, the distended ovaries had pushed the digestive tube aside, against the body wall. Perhaps it is sometimes so in *Chionea*, but in the females examined the digestive tube was found in the median plane, somewhat compressed between the ovaries, which being full of eggs bulged outward but were flattened medially.

Within the ovariole the egg lies with its anterior end (i.e., the end bearing the micropyle) away from the lumen of the ovary. The egg moves into the oviduct in this same position and thus is deposited posterior end first. Eggs in the dorsal part of the ovary are inclined downward, those in the ventral part upward, and so on, suggesting an inclined radial arrangement of the ovarioles around the lumen of the ovary (lateral oviduct). The eggs in both live females and those preserved in alcohol are whitish to very pale tan, those toward the anterior end of the ovary palest. They will be described later in more detail.

From its opening below the ninth sternum, the bursa copulatrix descends along the inner surface of the membrane between the branches of the furca (Figs. 22, 42, 44). It is only slightly curved cephalad near the base of the furca in some species (e.g., *Chionea alexandriana*, Fig. 22) but makes one complete loop in others (as *C. scita*, *C. nivicola*, Fig. 45). Approximately above the base of the furca there is a sclerotized thickening of the cuticular lining of the bursa, at which point the spermathecal ducts are given off. The lining of the bursa may be more extensively sclerotized and darkened, the degree depending upon both the species and the individual. In *C. valga*, for example, the bursa is very darkly sclerotized for most of its length.

Unexpectedly, the number of spermathecae was found to be either two or three. I would have expected a uniform number within the genus, but in females of *C. scita*, *C. nivicola* and *C. stoneana* there are three, while in *C. alexandriana* there are only two. The number of spermathecae could not be determined for every species because of a lack of properly preserved specimens in some cases; however, the bursa is ordinarily sufficiently sclerotized that it can be examined in cleared, slide-mounted specimens. It appears from such examination that the arrangement found in *alexandriana* (i.e., two spermathecae) occurs also in *lyrata* (Fig. 43), *nigra*, *excavata*, and other species of the *alexandriana* group. When there are only two spermathecae, the ducts open dorsolaterally on the bursa; when there are three, the third is medioventral in position. Also, when there are but two spermathecae, the ducts are large and thick-walled, while in species having three spermathecae they are thin-walled and slender. The ducts are

either well sclerotized basally, as in *stoneana* (Fig. 42), or contain spiral, ctenidia-like reinforcements near the base, as in the *alexandriana* group (Fig. 43).

The spermathecae are not sclerotized and of fixed size as in some other crane flies, such as *Dolichopeza* (Byers, 1961*b*: 701), but have membranous or semi-membranous (i.e., somewhat thickened yet translucent) walls and vary in size according to species, as well as with the volume of sperm contained. The female illustrated in Figure 19, for example, had distended spermathecae which were packed with sperm, but in some other females of the same species the spermathecae were small and wrinkled. The position of the spermathecae is highly variable, and the ducts are usually irregularly curved or even looped.

From the point at which the spermathecal ducts enter, the bursa copulatrix continues cephalad, terminating in a pouch (Fig. 19, fspth) that, like the spermathecae, has membranous to semi-membranous walls. It is large in females of the *alexandriana* group (the actual extent determined only in *alexandriana* but inferred from the part visible in slide-mounted specimens of the other species) but small to minute in other species. This appears to be the morphological equivalent of the "functional spermatheca" of *Dolichopeza* (Byers, 1961*b*: 703). In *Chionea,* however, I have never found any sperm in this pouch, while the spermathecae may be filled with them, as in the specimen illustrated (Fig. 19). The walls of this pouch are finely rugose, with abundant hair-like filaments extending into the lumen. The contents in preserved specimens are sparse aggregations of minute particles. Since the concentration of spermatozoa in the spermathecae is as dense as that in the vasa deferentia of the male, leaving virtually no space for any fluid carrier such as is probably produced in the male's accessory glands, it may be that the fluid portion of the semen received is stored in the pouch at the end of the bursa. Whatever its function, it is in some species a structure of considerable capacity situated where it is likely to be involved in the reception and storage of some part of the seminal fluid.

There are two accessory glands which empty by slender ducts (sometimes enveloped in a common sheath, basally, as Fig. 21) into the bursa just inside the aperture. These vary in size and general appearance from one individual to the next, being sometimes turgid and conspicuous (Fig. 19), other times so small and wrinkled as to be easily overlooked. Such differences are probably indicative of the physiological state of the organs at the time of preservation, the glands possibly being distended shortly before oviposition and collapsed after a batch of eggs has been laid. Closely app'ied to the membrane between the furcal arms and lying one at either side of the bursa are a pair of elongate, subhyaline, seemingly hollow structures (Figs. 22, 44, gl) of unknown function. These are usually very difficult to see. They appear to have no attachment to the bursa but may open to the outside near the ends of the arms of the furca. I have designated them "glands" (gl) with doubt.

Nearly all the major muscles in the eighth through tenth abdominal segments of the female are concerned with the deposition of eggs. Since I have not observed oviposition in *Chionea* and consequently do not know how the valves of the ovipositor move, I can only speculate on the function of certain of these muscles. Their origins, insertions and actions (see Figs. 20, 33) are as follows:

51. dorsolateral region of eighth tergum to anterodorsal corner of eighth sternum; elevates anterior end of eighth sternum.

52. lateral ends of eighth tergum to side of eighth sternum, below margin and beside gonopore; elevates eighth

sternum. Note: it cannot be surely said which of the described attachments is the origin and which the insertion.

53. anterior eighth sternum to lateral portion of ninth sternum; draws ninth sternum downward. Note: muscle pairs 51-53 probably function to bring the gonopore and the opening of the bursa copulatrix into proximity so the eggs can be fertilized at the time they leave the oviduct.

54. side of eighth sternum to opposite side, passing just beneath and behind common oviduct; draws sides of sternum and therefore bases of hypovalves together. Note: this unpaired muscle together with pairs 51 and 52 may be involved in extrusion of the egg from the posterior end of the oviduct.

55. posterodorsal eighth sternum to anteroventral hypovalve; elevates hypovalve.

56. dorsal ninth tergum to base of cercus; depresses cercus (see also m-58).

57. dorsolateral ninth tergum to lateral ninth tergum near attachment of ninth sternum; elevates ninth sternum.

58. dorsal tenth tergum to base of cercus; depresses cercus (see also m-56).

59. transverse, infolded ridge on tenth tergum to upper base of cercus; elevates cercus. Note: the elevators of the cerci are very small, while the depressors are large, indicating that the cerci are probably drawn down against the hypovalves during oviposition.

60. lateral tenth tergum to lateral tenth sternum; elevates tenth sternum.

There are some lesser muscles associated with the furca, including those between the furcal base and the oviduct (Fig. 22, mfb). The membranous body wall at each side of the pouch (Fig. 22, pch) between the furca and the distal roof of the oviduct also contains a wide, thin sheet of muscle attached to the furca.

NATURAL HISTORY OF CHIONEA

Ecological Distribution

Although there is a slowly growing body of knowledge about the underground habitats of *Chionea,* the fact remains that most of what we know about these flies is based upon their occurrence on the surface of snow. Against the white background of snow even the palest *Chionea* is conspicuous, especially when moving. In contrast, the flies would be easily overlooked in the winter surface vegetation, which is largely dead and dried to dull browns and grays. On the surface of snow, species of *Chionea* may be found together with such other winter insects as *Boreus* spp. (Mecoptera: Boreidae), various apterous, brachypterous or even fully winged stone-flies (Plecoptera: Nemouridae, especially Capniinae), gall wasps (Hymenoptera: Cynipidae) of the agamic generation, several kinds of snow-fleas (Collembola: Poduridae and Isotomidae), certain Chironomidae, Anthomyiidae, and a few taxa of non-insect arthropods, notably spiders. By "found together," I mean they occur in the same general environment. Insects on the snow are usually widely dispersed, and I have never seen any direct interaction of a *Chionea* with any of the other kinds of arthropods mentioned.

Activity of winter insects on the snow seems to be limited mainly by temperature and to a somewhat lesser extent by wind and blowing snow. Light intensity may also be an important factor in the case of *Chionea,* as will be discussed later, but its effect is not readily separated from that of temperature.

While the relationship of such physical factors of winter environment to the distribution and abundance of various insects has been examined by several authors, few of these studies have direct bearing on the biology of *Chionea.* Cold hardiness in some European winter insects, including *Chionea araneoides* Dalman, was studied

by Sömme and Östbye (1969). They found this *Chionea* active chiefly at air temperatures of 0 to –4°C, occasionally at –7°C (near 20°F). They determined that it is able to avoid the lethal effects of freezing of its haemolymph by supercooling to –7.5°C. From his field observations of *C. araneoides,* Hågvar (1971) determined –6°C to be the lower limit of activity and found the flies most commonly on the snow at air temperatures between –4 and –5°C when there was no appreciable wind. He seldom saw this species on the snow at even slightly higher temperatures (–3 to 0°C) and concluded that their activity is very narrowly limited by temperature. Wojtusiak (1950) found *Chionea* (*lutescens* and "*hrabei*") active primarily around –3.5°C. Bezzi (1919) reported *Chionea* spp. active at temperatures down to –6°C.

Chapman (1954) similarly found some North American Chioneas (mostly *C. alexandriana*) active on snow at air temperatures in the range of –7 to 0°C but mainly between –4 and 0°C. He also found *C. alexandriana* in cold stupor at –7.5°C (19.5°F). His observations are in close agreement with those of Sömme and Östbye.

Throughout the range of *Chionea,* winter temperatures far below this tolerable level of approximately –7°C are frequent and often of many days' duration. It is accordingly imperative that the flies have ready means of escape from severe cold. Routes for movement from the snow surface to the soil are easy to find when one is in the natural habitats of *Chionea.* They may result from accumulation of gently falling snow on low vegetation, often leaving adequately large openings to the soil. Others occur around large trees and rocks, where surface wind may arrange the snow in such a way as to leave large, funnel-like depressions leading to the soil or nearly so. Winds also move brush, saplings and other vegetation protruding above the snow surface from side to side, with the result that around the stems of such plants there are narrow channels leading down to the ground.

The insulating effect of snow cover on the soil cannot be overemphasized. Mail (1930: 579) showed that temperature just below the soil surface (habitat of larval Elateridae, or wireworms) fluctuated only about 4°C (–1 to 3°C) over a month of observations (January), while air temperature above the snow varied from –2 to –23°C around a mean of about –14°C. He also demonstrated (p. 577) the cooling effect of air temperature on the soil in the absence of snow cover. Coulianos and Johnels (1962) recorded similar results for the subnivean environment of small mammals. (The subnivean air space results when snow is held away from the soil surface by grasses and other low vegetation; it may be enlarged by the activities of mammals or perhaps by heat generated by bacterial decomposition of leaf litter or other dead vegetation.) These investigators found that over a 14-day period in March in Sweden, the temperature in a 5 cm subnivean stratum beneath 20 cm of snow varied only from 0 to 2°C, while during the same period daily maximum temperatures fluctuated between –6 and 0.5°C and nightly minima between –4 and –23.5°C. In another study of microclimates to which small mammals are subjected, Hayward (1965) found that in burrows of *Peromyscus* mice in alpine, subalpine, mesic and arid habitats, winter temperatures never fell below 0°C. (Although it is not particularly relevant here, Hayward further found that in summer, when air temperatures during a day might fluctuate 15.2 degrees, from 4.6 to 19.8°C, the temperature in representative mouse burrows remained very close to 10°C.)

I have made similar comparative measurements of temperature in the soil, in the snow cover, at the snow surface and in the air several centimeters above the snow surface. My findings, while only made

on certain days and in various winters, not over a span of many days, agree with those presented here.

By seeking refuge in soil cavities, in rodent burrows, or in the subnivean air space, *Chionea* can not only escape severe cold at the snow surface but can in fact enjoy a habitat where the temperature is relatively stable, probably near the optimum for the adults, and where the humidity is relatively high. In view of these effects of snow cover, one wonders if *Chionea stoneana,* our least boreal species, might not be also our most cold-hardy *Chionea,* living as it does in a mid-continent region where winter temperatures are often very cold but where snow cover is frequently absent.

Where Chioneas are and what they are doing when they are not on the snow surface is only sketchily known. Chance observations by a number of authors have appeared chiefly in the European literature. Bezzi (1919) summarized 67 collections of *Chionea* made up to 1917 in Europe and Asia. He recorded six collections from caves (two from France, four from Jugoslavia), two from vacant underground wasp nests in Belgium and the Netherlands, and one from the burrow of a meadow vole (*Arvicola*). Bezzi did not regard *Chionea* as a cavernicolous insect but supposed that the flies had only accidently wandered into caves in search of smaller cavities in which to conceal themselves. There are sufficient records from caves in the United States, however, to convince me that *Chionea,* while perhaps not a cavernicole in the strict sense, is more than an accidental visitor in caves. There have been a few subsequent discoveries of *Chionea* in European caves (e.g., Strinati and Aellen, 1967).

In a study of cave insects, Dr. M. S. Briscoe of Howard Univ. set a number of pitfall traps (glass jars) in the floor of a cave near Harpers Ferry, West Virginia. These were baited with decomposing meat and were intended to attract primarily cave-dwelling Coleoptera. In addition to the beetles and various other insects, Dr. Briscoe trapped 29 specimens of *Chionea scita,* a larger collection of this species, by far, than any ever made from the snow surface. The traps in which *C. scita* was found, Dr. Briscoe informed me, were set 100 ft (31 m) or more inward beyond the border of total darkness in the cave.

During summer months crane flies are not uncommonly found in the entrances to caves, that is, in those parts of the cave that afford shade from the sun and increased humidity but are not isolated from the more normal environment of the flies; but such crane flies rarely venture into a cave beyond the zone of deep twilight. Graham (1966) has given an account of this, as well as of the occurrence of the trichocerid flies *Diazosma subsinuata* (Alexander) and *Trichocera columbiana* Alexander in the zone of total darkness. I have occasionally found large numbers of mosquitos and fungus gnats hibernating in parts of caves that were totally dark yet not a great distance from the opening. It is likely that some fungus gnats (Mycetophilidae) can breed in caves, where such organic debris as bat guano accumulates on the floor to provide adequate substrate for the growth of fungi which in turn nourish the larvae. While the diet of larvae of *Chionea scita* is not yet known, there is a strong likelihood that it is comprised in part of organic debris of various sorts. It is thus not improbable that the population sampled by Briscoe had become established in the cave.

Mr. Roger Sperka (pers. comm.), then of the Univ. of Kentucky, collected a female of *C. scita* in Wind Cave, Pulaski Co., Kentucky. He estimated that the fly was found 700 ft (215 m) from the entrance and in a lateral tunnel, thus far beyond the darkest crepuscular zone and in total darkness, where the temperature was 51.5°F (11°C). However, the single individual had fallen into a small stream

in the cave, had clambered out again and "seemed disoriented," so there is reason to suppose it may have strayed from some area of the cave where a population of its species might have been established, if not from outside the cave.

Other records from caves involve primarily western species taken considerably closer to the cave entrances. The flies in these instances could have been accidental visitors. A collection of special interest is that of *Chionea alexandriana* from an ice cave in Union Co., Oregon. The single male in this collection of 18 individuals has gonapophyses of an atypical form not seen from elsewhere in the range of the species.

Underground habitats of *Chionea* other than caves consist almost wholly of burrows constructed by other kinds of animals. These vary in size from burrows of earthworms (Kryger, in Edwards, 1936) to nest burrows of wasps (Bezzi, 1919) (conceivably enlarged from rodent nests) to burrows and nests of mice and voles.

Hackman (1961, 1963*a*, 1963*b*) has made the most detailed and systematic study of Diptera in excavations made by small rodents. Among some 2000 individual flies of 240 species, he found only one *Chionea*, a female of *C. lutescens*. This fly was in a burrow of *Clethrionomys glareolus* beneath a tree stump in southern Finland. Hackman (1963*a*) regarded *C. lutescens* as a xenocoenic species, that is, one that is foreign to the community in which it has been found (in this instance the burrow community) and actually adapted to life in some other kind of habitat. Trichoceridae, or winter gnats, were common in his winter samples; he found four species of these (also two of the crane fly genus *Ormosia*, but not in winter). These he regarded as tychocoenic, generally adapted to the burrow environment but with a wider ecological range enabling them to thrive in other, similar biotopes as well. Hackman concluded that *Chionea* merely utilizes the vole burrow as a shelter against unfavorable weather in winter, although he pointed out that the deep burrows communicate with runways in the subnivean air space. In his interpretation of the presence of *Chionea* and *Trichocera* in burrows of *Clethrionomys*, he possibly overlooked one aspect of the biology of these flies, that is, larval diet. Larvae of *Trichocera* develop in decomposing organic debris such as may accumulate in rodents' excavations, particularly nests. There is also reason to believe that such nest debris (e.g., feces of mice) is involved in the diet of larvae of *Chionea*. That is, I am suggesting that *Trichocera* and *Chionea* may spend much of their respective life cycles in rodent burrows.

The extent to which rodent burrows or nests are utilized by North American species of *Chionea* is not known. We may make some inferences, however, from certain facts about *C. stoneana* and *C. scita*. Investigation of arthropods in nests of the prairie vole, *Microtus ochrogaster* Wagner, by Philip C. Stone of the Univ. of Illinois, led to the discovery of the specimens upon which Alexander (1940) based the description of *C. stoneana*.

Fourteen adult males and five females of *C. stoneana* were collected from cavities beneath large logs, apparently abandoned mouse nests (probably of *Peromyscus leucopus*), on 2 January, in a sparse oak-hickory woodland in northern Franklin Co., Kansas. The nest material upon which the adult flies were walking, and from which numerous larvae were subsequently recovered, consisted of finely shredded, decayed wood, small fragments of dead leaves and grass stems, and some loose soil particles. Arthropods associated with the Chioneas included small, active staphylinid beetles and some hibernating, inactive wood cockroaches, ants, lygaeid bugs and a machilid. Further details are found in the account of *C. stoneana* following.

A habitat in southern Michigan from

which I obtained several individuals of *C. scita* was in many ways similar to that just described. The flies were in cavities beneath two old, rotting stumps, where the accumulated material comprised shredded or crumbled decayed wood and bits of dead leaves and grasses. Both stumps were about 3 m from the marshy edge of a lake, about 50-60 cm above the water level.

It has been noticed from the time of Bezzi's 1919 monograph onward that *Chionea* species are found only in environments that are to some extent forested. It is furthermore clear that the particular kind of forest is not a factor in the ecological distribution of *Chionea* at the generic level, nor does it seem to be for any species. Trees, of course, may play a dual role in the environment of *Chionea*, shading the terrestrial habitat in summer to provide a more nearly uniform temperature the year around, and serving as windbreaks in winter when *Chionea* is on the snow surface.

In eastern North America *Chionea* occurs in deciduous woodlands, such as the relatively dry oak-hickory or the more moist, boreal-montane beech-maple associations, also in mixed deciduous and evergreen forests of eastern Canada. In the western mountains, *Chionea* may be found from the rather low and dry forests of ponderosa pine (western yellow pine), through the higher zone of lodgepole pine, and in the high alpine forests of spruce and fir. Within these various kinds of forests, *Chionea* often is found in clearings or areas of sparse timber and along streams, less often in dense stands of trees. In contrast, no species seems to occur on treeless plains or in mountains above timberline (although *C. nigra* has been collected up to 11,400 ft (3500 m) in the Rocky Mountains of central Colorado, which is just below timberline at that latitude). Wherever *Chionea* occurs, there will be found some vegetation penetrating through the snow cover. It should be borne in mind, though, that these insects are strong walkers and may wander an appreciable distance from such vegetation. A case in point is the discovery by E. N. Pruitt of *C. valga* on the ice of frozen Lake Huron, northern Michigan, 46 m (50 yards) from the shore.

A further observation concerning the general habitat of *Chionea* is that the terrain is nearly always rocky, that is, with protruding rocks here and there. This has not proved true for most habitats of *C. stoneana*, however. Sufficiently large rocks are likely to have the snow drifted around them in such a way as to give access from the soil to the snow surface. Durbin (1975: 139, Figs. 16, 17) illustrates this very well. It has occurred to me that, at least in the habitats of the lowland eastern species, this association of *Chionea* with rocky places may derive largely from the works of humans. That is, where the land is more or less level and not rocky, it has been cleared of trees and used for agriculture.

Geographical Distribution

North American species of *Chionea* fall into two main distributional groups, eastern and western, which have no relation to the taxonomic groups already discussed.

The eastern geographic group (*valga, scita, stoneana* and *wilsoni*) includes fairly widely ranging species that have so far been taken only at relatively low elevations. As a group these have spread out over a vast area more than 2000 miles from east to west and over 1500 miles (21 degrees of latitude) from north to south. An interesting aspect of this extensive distribution is that a major part of the ranges of three of these species falls within the area that was glaciated at various times during the Pleistocene and was overlain by ice as recently as about 10,000 years ago. Nearly the entire range of *C. valga*, the most widespread species in the genus, is

in the formerly glaciated region. There is no reason to suppose that the range of *valga* was displaced very far to the south of the glacial border during the Wisconsin advance, but even so the flies must have walked some 1200 miles (or more, depending upon the range during the glacial maximum) to reach certain portions of the species' present range. This sounds impressive but actually amounts to somewhat more than 195 m (210 yards) per year, probably not an unusual distance for an individual *Chionea* in its lifetime. (I am not considering any more rapid means of dispersal than the insects' own movement.)

It is often the case that tipulids having such a boreal forest distribution as that of *C. valga* also occur southward through the Appalachian Mountains, but on the basis of available evidence this seems not to be generally true of *valga*. Although the southernmost part of its range is in the Appalachian region, the collection localities are not particularly montane. However, the southernmost record of *C. scita* in northern Georgia is decidedly montane, about 3200 ft (985 m) above sea level.

Even more a species of the flat-lands is *C. stoneana*, which possibly was isolated in the Ozark-Ouachita region during the Wisconsin glacial advance and which has, as far as we know, moved only 450 mi or so into formerly glaciated territory.

In contrast, the western geographic group is primarily montane in distribution. Only about the northern one-fourth of the group's range was covered by the continental ice sheet, but doubtlessly the rest of it was influenced by extensive mountain glaciers during the late Pleistocene. The combined ranges of the 12 western species (*albertensis, alexandriana, carolus, durbini, excavata, hybrida, jellisoni, lyrata, macnabeana, nigra, nivicola* and *obtusa*) cover an area about 1,600 mi from north to south and about 1,300 mi from east to west. Within this area, however, the ranges of the various species of *Chionea* apparently follow the mountain chains, leaving broad "vacant" areas, such as in the northern Great Basin.

Collection of the snow-inhabiting mecopteran, *Boreus*, in such far northern localities as the Pribilof Islands and central Alaska invites speculation about whether *Chionea* might not also occur there. Representatives of the two genera are often found together on snow in both eastern and western North America, suggesting they have a number of ecological requirements in common. Both genera are flightless, *Boreus* therefore having no obvious advantage in distribution. Observations of *Chionea nigra* and *Boreus coloradensis* in the Rocky Mountains of central Colorado indicate that *Chionea* is even more tolerant of low temperatures than is *Boreus*. It seems unlikely, however, that *Chionea* will be found in the Arctic or in subarctic areas north of approximately 60°, except where proximity to the ocean has a moderating effect on temperature. The winters in this region are probably too harsh—the temperatures persistently too low.

These distributional data emphasize that the ranges of the western species in particular, but of the eastern ones as well, are still only sketchily known.

Seasonal Distribution

It is not practicable to attempt to summarize the seasonal occurrence of *Chionea* in North America except in the most general way. Data on seasonal distribution are given in detail and briefly summarized for each species in the taxonomic accounts which follow. There are collection records of one species or another for every month from September through May, with peaks of abundance of adults coming generally in October-November and February-March.

Variables in seasonal distribution of any species include latitude and elevation of the collection site and the weather of the particular year. Latitude is of greatest

importance in such a species as *Chionea valga,* the range of which spans more than 15 degrees of latitude but includes little altitudinal variation. Elevation, of course, influences the season of appearance of adults mainly in the western montane species. Since weather can vary so greatly from one year to another, the data on seasonal occurrence based on occasional chance collections are not very meaningful. Detailed studies in certain areas over an entire winter are more significant. Chapman (1954), for example, found peaks for *Chionea alexandriana* in western Montana, between 3600 and 7000 ft, in November-December and February-early April (but the species was still present on the snow in mid-May). Somewhat further south but at higher elevations, 9500-11,200 ft in the Rocky Mountains of Colorado, Osburn (1958) found *C. nigra* most abundant in October-November and late February-April. In the Sierra Nevada, at 6200 ft, Durbin (1975) found adults of *C. carolus* from early November to early February, with a clear peak of abundance in December.

Longevity of Adults

Most summer crane flies have a rather ephemeral existence as adults—generally a few days, some surviving for perhaps a week or ten days under most favorable conditions. In contrast, species of *Chionea* are relatively long-lived, the supposition being that cold winter temperatures slow their physiological processes and proportionately increase longevity. It is not yet possible to state the duration of adult life of any species of *Chionea* because no individual fly has ever been observed from its emergence from the pupa to natural termination of life. The longest I have kept adults was 19 days after they were collected. Edwards (1936: 89) recorded survival of *Chionea lutescens* for 62 days, including a trip by air-mail from Denmark to London. I anticipate that adult longevity of two months will be found not uncommon in North American species though it will not be easy to determine. Removal of the insects from their natural surroundings may spare them from predation or severe weather, but I suppose any laboratory environment has its own perils that may not be evident to the entomologist.

Long adult life could be viewed not only as a physiological response to cold but also as an adaptation to fluctuations in weather. There are likely to be periods of many days and nights together when the air temperature remains below the level at which *Chionea* can survive. Accordingly, activities that normally take place on the snow (or other) surface have to be postponed. A prolonged period of adult emergence (from the pupal stage) would of course also help to overcome this environmental obstacle, but so far we have no data that would separate this from individual longevity.

Behavior

What follows concerning the activities of adult Chioneas is derived partly from data recorded by others but largely from my own occasional observations of various species in the field and from observations of two dozen individuals of two North American species (*scita* and *stoneana*) and a smaller number of a Japanese species kept alive in the laboratory for varying lengths of time up to 19 days. To learn the details of the behavior of *Chionea* it will probably be necessary to devise an observation terrarium in which many individuals can be successfully maintained over a long period of time under conditions somewhat resembling those in their natural environment. This should include an underground cavity glassed on one side but shielded except during observations and provided with finely shredded, decayed wood or other such material as may be found in mouse nests in the ground. Pro-

vision should be made for temperature control sufficient to prevent overheating. I hasten to add that I have not constructed such elaborate quarters for the few Chioneas I have caged and watched, but my observations are only fragmentary and could have been much improved by an arrangement such as that described.

Observations of *Chionea* above ground —that is, on the snow or some artificial substitute for it—reveal only a fraction of the adult insect's total activities. This, of course, may prove to be the major fraction, but whether adults of *Chionea* are essentially inactive when underground or otherwise in darkened surroundings remains to be learned. When caged without access to places of concealment, Chioneas spend long periods of time virtually motionless, both by day and by night. When thus at rest they assume a characteristic posture (Fig. 50) in which the legs are drawn up more or less vertically against the sides of the body, the tibiae closed against the femora, and the tarsi beyond their basal segments appressed to the ground in a somewhat radiating pattern, so that the insect is suspended with its venter only slightly off the substratum. While in this resting position, the flies often raise and lower the body slowly and rhythmically by moving the folded legs first outward with the feet in place, then inward, so that the femora are once more against the sides of the body. This movement recalls (but does not resemble) the much faster, vibrating motions seen in some other limoniine species, notably in the subgenus *Geranomyia* of *Limonia*.

On several occasions I have observed a defensive behavior in *Chionea*. When moderately alarmed, the fly draws its legs close together above the body in a way that resembles the resting posture just described. The legs, however, are held even closer together and inclined backward, the femoro-tibial joints nearly in contact. This is probably the posture observed by Blurton (see Treherne, 1920: 201), who noted that *Chionea alexandriana* when approached would ". . . crouch down . . . as if it could feel the vibrations in the snow made by the weight of my snowshoes." In this position the fly stands motionless until the source of alarm has passed. This is probably its most effective means of avoiding such dangers as predation by birds, for with the legs drawn together above the body and somewhat laid back along the abdomen, the insect, seen from a few feet away, could well pass for a chip of bark or some other bit of darkly colored detritus such as one commonly sees on the snow in forested areas.

When greatly alarmed, *Chionea* ordinarily resorts to "running" or much less frequently to leaping. The running is actually a brisk walk, whereby the insect may move about four feet in a minute. I do not know whether females of *Chionea* are able to leap, but I have seen males jump distances greater than six inches (though usually much less). They sometimes jump without evident provocation, as in the case of a male of *C. scita* that suddenly leaped from the edge of a dish to the front of my shirt as I was watching its movements. Usually, however, *Chionea* jumps only in response to extreme alarm, such as when touched with a stick or other object. Females so stimulated did not jump.

Most often when Chioneas are encountered on the snow surface, they are walking with their characteristic, slow, deliberate gait. Their movements are not rapid and erratic, stop and go, this way and that, like those of so many other insects. In contrast, they proceed in an almost straight course over relatively long distances, treading the snow with such steady, rhythmic cadence and seemingly measured paces that they almost appear to be marching and to know where they are going. Watching the actions of *Chionea alexandriana*, Blurton (see Treherne, 1920: 201) was

similarly impressed and wrote: "When travelling over the snow they always appear to be in a great hurry, and they move in nearly straight lines from one point to another . . . as if they had some special destination in mind." At this pace of about 80-100 "steps" per minute, *Chionea* can in that time travel 2-3 ft across the snow.

Marchand (1917) published a rather detailed account of the behavior of one individual of a European *Chionea* and from his observations arrived at some interesting conclusions about the species. He caged the insect in a glass box, the sides of which it climbed, and he interpreted this activity as a demonstration of negative geotropism. When the box was covered at each end by panes of glass, with a screen cover in the middle, and the *Chionea* repeatedly came to rest upon the screen, Marchand saw in this an attraction to cold temperature, or negative thermotropism. In both these instances, however, it seems the insect might merely have been trying to get out of the box. Marchand believed that the Chionea's retreat from his approaching hand was a reaction to heat, and he gave no consideration to the possibility that a human hand might have somewhat the same effect on a tiny insect as the approach of some predator. Some of Marchand's other conclusions were that *Chionea* must keep moving over the surface of the snow because it might freeze if it stops, that because one time the fly was observed walking into the wind the species may be positively anemotropic, and that exposure to sunlight caused the death of a *Chionea*.

I have not observed living Chioneas sufficiently to discuss most of Marchand's conclusions, but one of them—that *Chionea* is positively phototropic and is attracted to brightly illuminated snow—is in general contrary to my observations and ought to be examined. While watching adult Chioneas under the microscope, I noticed that they rather consistently avoided the light. This, of course, could have been a reaction to heat, although I was using cooled illumination. To explore the matter, I made a small house of cardboard with a door only large enough to let the insects pass in and out, and set this in the covered glass dish in which a male and a female of *Chionea scita* were kept. After three hours both flies were still sitting motionless outside the house. By 8:30 the next morning, however, the female was inside, and by 10:00 the male also had gone in. Thereafter, for eight days (after which observations were discontinued), the general pattern of their behavior was that the flies went into the house during the brighter hours of the day but were often outside in early morning, in the evening, or at other times of day when the sky was very cloudy. During these observations the flies were subjected to fluctuating outdoor winter temperatures on the north (shaded) side of a building in southern Michigan. Subsequently, it was my observation that *Chionea* is more likely to be found on the snow when the light intensity is reduced than in bright daylight. For example, I once searched several hours for *Chionea* in the afternoon of a clear day and found none. But as the sun sank low over the mountains and the shadows lengthened, several individuals of *Chionea* appeared in the very places I had sought them earlier in the day. Occasionally I have found them still on the snow surface after nightfall. I asked some other entomologists (John A. Chapman, William S. Osburn and David V. Durbin) to note light conditions at the time of capture of *Chionea,* and again—although not without exception—the flies were found late in the day, at evening, or on cloudy days, occasionally in early morning or during a snowfall. To this evidence could be added the similar observations of Lugger (1896: 230) and the capture of *C. scita, C. alexandriana* and *C. valga* in caves and of *C. stoneana* in rodent burrows. There are, however, two

interesting pieces of apparently contradictory evidence. In Carbondale, Illinois, Dr. John Downey found a male of *C. stoneana* climbing the outside wall of a house, apparently attracted to a porch light, at about 11:00 P.M.; and in University Park, Pennsylvania, Dr. C. W. Rutschky collected a female of *C. scita* on a window screen, possibly attracted to light, again about 11:00 P.M. Perhaps, however, there is no real conflict between these observations, for it is quite possible that *Chionea*, like so many kinds of moths and other crepuscular and nocturnal insects more familiar to entomologists, is repelled by bright light, such as that of the sun during most of the day, but attracted to lights of low intensity.

I would agree with Marchand that the snow surface holds some special attraction for *Chionea;* that is, I do not believe its occurrence there is only coincidental. Although there is strong evidence that Chioneas are primarily underground insects, the great number of collections of them from the snow surface indicate the flies come there with some regularity and therefore very likely for some reason. Hagvar (1971) supposed that narrow limits of tolerance of temperature and wind led to the simultaneous appearance of numerous individuals of *C. araneoides* on the snow

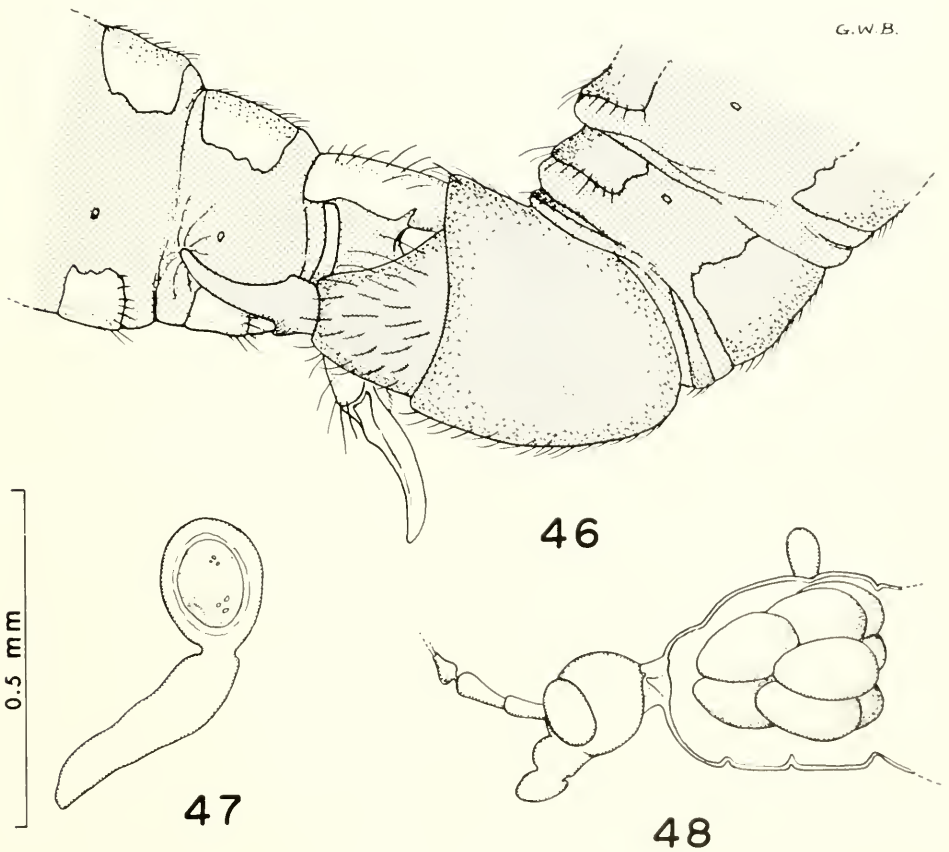


Fig. 46, *Chionea jellisoni*, terminal abdominal segments of male (sclerites shaded) and female, to show relative positions during copulation. Fig. 47, cysticercoid of tapeworm, probably *Hymenolepis* sp., from abdominal cavity of adult female of *Chionea stoneana*. Fig. 48, *Chionea nivicola*, female, to show position of eight eggs in thorax in space made available by absence of indirect flight muscles. Scale: Fig. 47.

surface. Repeated observation of mating of the flies on the snow would support the suggestion of various authors that the reason is the bringing together of the sexes. It has also been suggested (Marchand, 1917: 150) that Chioneas are visually attracted to each other and find one another more readily because of the contrasting background afforded by the snow. It is true that they are conspicuous when seen from above against a white background, but if one scans the snowy terrain from a millimeter or so above the undulating surface—that is, adopts the insect's view of things—the idea of visual attraction becomes somewhat less convincing. Moreover, as discussed earlier under external morphology, the eyes of *Chionea* probably do not afford much visual acuity.

To say that the flies come out onto the snow surface so that males can find females is not a very thorough explanation of their presence there. Where *Chionea* has been found anywhere except on snow, both males and females have ordinarily been taken together in restricted microhabitats such as mouse nests, cavities beneath logs or rocks, in caves, rodent burrows, abandoned wasp nests, etc. Surely they are able to locate one another in such confined places. It occurs to me, however, that since *Chionea* is an insect of low vagility as compared to winged tipulids, and since it does live in groups (probably the progeny of one female) in partially isolated or restricted pockets, there might develop a degree of inbreeding detrimental to the species unless there was some device for bringing about a mixing of genes. Among winged Tipulidae reaching the adult stage in warmer weather, this may be accomplished by mating swarms (in which, of course, there still may be some inbreeding), or by more or less random flight by one or both sexes prior to mating. I regard the appearance of *Chionea* on snow as partly, at least, a means of effecting genetic recombination. Certainly, the relatively smooth surface of snow is less of an impediment to the movement of strictly pedestrian insects in search of mates than would be vegetation at the soil surface whether snow-covered or not. In addition, it is known that *Chionea* is a strong walker and may cover substantial distances; accordingly, wandering over the snow is probably important to the distribution of the flies into new microhabitats.

Mating Behavior

Several entomologists have commented on the rapid reaction of males and females of *Chionea* to each others' presence when placed in the same container. Lugger (1896), for example, observed that when a male and female (probably of *C. stoneana*) were caged together ". . . the snow-flies immediately mated, notwithstanding it was several degrees below the freezing point." When I placed two males and two females of *C. scita* in a large vial lying on its side, in the field, they formed two mating pairs almost at once. These pairs separated during the return trip to the laboratory, but soon after the flies were put into rearing dishes they mated again. During the first three days after capture these same pairs of flies mated at least once daily, again on the fifth and sixth days, and once more on the eighth day. No mating behavior was seen thereafter; however, I was observing the flies only occasionally and probably failed to note all matings. Duration of mating was about 30-70 min but may be much longer.

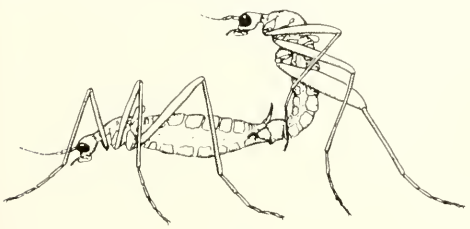
On the basis of my observations of four species of *Chionea,* I can state that mating behavior is essentially the same in all. The male approaches the female ordinarily from behind, rising high upon his legs as he does so, with his body oriented almost vertically. His abdomen is then curved forward so that the hypopygium can grasp the female's ovipositor. But instead of facing in opposite directions during copulation, as is usual among crane

flies that mate while standing on a surface, with one or both partners' abdomen rotated, both flies face in the same direction with the male's abdomen curved so that the hypopygium is inverted to achieve the usual tipulid arrangement, that is, with the male genitalia rotated 180 degrees in relation to those of the female (Fig. 49). Mik's description of the mating behavior of a European species of *Chionea* agrees with this (Osten Sacken, 1887: 196).

The male's dististyles secure a grip in the pleural membrane of the female's abdomen just cephalad from the strongly sclerotized eighth tergum. The hypovalves of the female are inserted beneath the male's ninth abdominal tergum, which deeply indents his membranous tenth segment, and the curved cerci are directed upward between his outspread basistyles (Fig. 46). Although the male's fore and middle legs touch the substrate during mating, it is the hind legs that must carry his weight and brace him against the female in this copulatory stance.

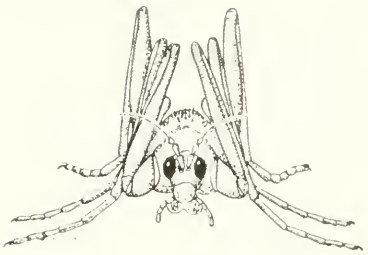
Males occasionally approach other males in the manner described above, suggesting a strong visual orientation to general shape and motion (but a lack of visual acuity) and perhaps the absence of chemical attraction in *Chionea*. Such encounters, however, are always brief.

Mating, as other activities of adult Chioneas, may take place at nearly any time of the day and under slightly subfreezing conditions. I have observed it more often at temperatures from 0-2°C



49

Fig. 49, mating pair of *Chionea scita,* showing typical posture, with male supported chiefly by his hind legs.



50

Fig. 50, *Chionea scita* in resting posture, frontal aspect.

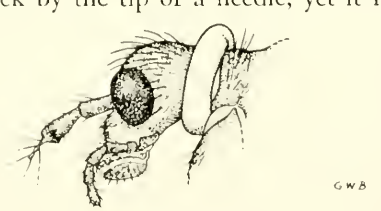
(about 32-35°F) and at times of low light intensity, particularly late in the day.

Parasites and Predators

Two kinds of helminths have been found associated with North American species of *Chionea*. In a series of *C. stoneana* from a mouse nest in eastern Kansas, I found cysticercoids of a species of tapeworm (Platyhelminthes, Order Cyclophyllidea) in the abdominal cavities of two out of three specimens dissected. These (Fig. 47) closely resemble the cysticercoid stage of *Hymenolepis* but have not been authoritatively identified. Ten were found in a male specimen in which the viscera were only slightly reduced in volume, but in a female containing 31 cysticercoids (28 in the abdominal cavity and three in the thorax), there were no eggs, although the spermathecae, appeared of normal size and contained closely packed spermatozoa. It is, of course, possible that she had laid all her eggs, though this seems unlikely, considering the condition of the other individuals collected at the same time. *Hymenolepis diminuta,* a common and widespread parasite of mice and rats, has been shown to pass its immature or cysticercoid stage in a variety of insects, including meal moths and their larvae, earwigs, *Tenebrio* grain beetles, *Tribolium* flour beetles, and larval fleas (Cheng, 1973). The insects become infested by eating eggs of the worm in the feces of the primary host and ingestion of the parasitized insects in turn serves to reintroduce the larval worms

into the rodent, completing the cycle. From this evidence it seems reasonable to infer that whatever sort of mouse made the nest shared by *Chionea stoneana* (probably *Peromyscus leucopus*) is also an occasional predator on the fly. It is possible, moreover, that *Chionea* is often the intermediate host of such tapeworms among species of mice that in winter have no access to such indoor insects as those enumerated above (the flea being an exception). The type specimens of *Chionea stoneana* were found in nests of the meadow mouse or vole, *Microtus ochrogaster,* in Illinois; and in northern California *C. alexandriana* was found in an abandoned nest of the pack rat, *Neotoma* sp. (not identified at the time but probably *N. cinerea,* according to Dr. Robert Hoffman). There are also a few records of European species of *Chionea* from nests of rodents (see Bezzi, 1919). It must be that the eggs of the tapeworm are eaten by the *Chionea* larvae, since adult Chioneas probably take no solid food; and this knowledge offers some information about the larval diet.

In the case of the second helminth associated with *Chionea,* the relationship is apparently not one of parasitism but rather of phoresy. The worm is an unidentified species of nematode. At first glance an affected fly appears to have the neck membrane swollen, but closer examination reveals that there is a ring-like capsule around the neck, thin walled and somewhat the shape of the inner tube of an automobile tire (Fig. 51). It is not attached to the insect and often can be rotated on the neck by the tip of a needle, yet it fits very closely and cannot be slipped off over the head. Within the capsule are a large number of immature nematodes, which after a time rupture the capsule wall and emerge. Although I have seen only preserved specimens, they show various stages of increasing development of the nematodes within the capsule and then of their leaving it. The only suggestion that these worms might enter the body of the fly comes from the rare discovery of a few nematodes clinging to the thoracic sternum or about the leg bases of Chioneas with a half empty capsule around the neck or with no capsule remaining. None of these nematodes, however, has been found to have actually penetrated the fly's exoskeleton.

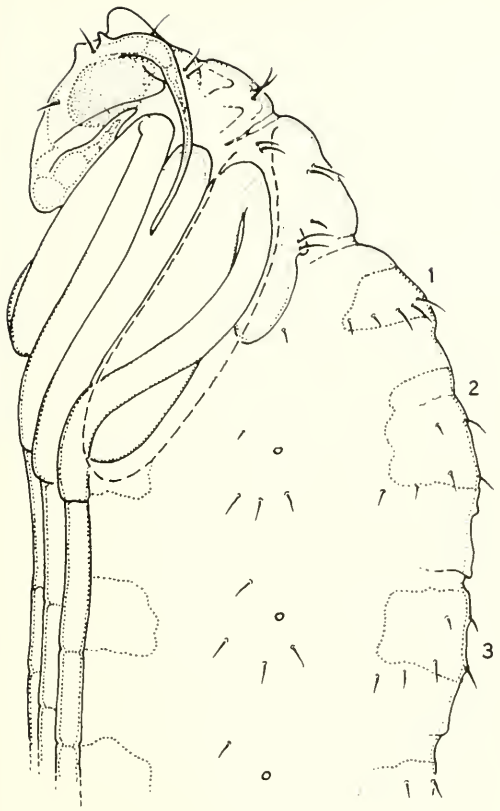


51

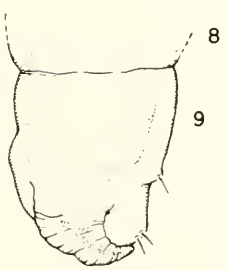
FIG. 51, *Chionea alexandriana* with egg case of nematode around its neck.

Dr. May Belle Chitwood (pers. comm.) determined that these nematodes are closely related to *Rhabditis,* some species of which are known to utilize insects as "hosts" for the purpose of transportation. In a discussion of the family Rhabditidae (order Rhabditata), Cheng (1973: 623) mentioned that parasitic forms of these nematodes may depend upon coprophagous insects to carry them from one host food source to another. It is possible that *Chionea* is used by the nematode as a means of travelling from one mouse burrow to another in order to parasitize the rodents. Or the *Chionea* may be merely a device for providing the nematode a generally more widespread distribution, if it is a free-living form. In any event, the female nematode probably places her egg capsule (which may be a more solid, gelatinous ring at the outset) around the fly's neck at the time of its emergence from the pupal skin, for it is at that time that the fly is least mobile and least able to avoid such treatment. I have speculated freely in the interpretation of these nematode capsules, but whatever the true story, it must be a very interesting one.

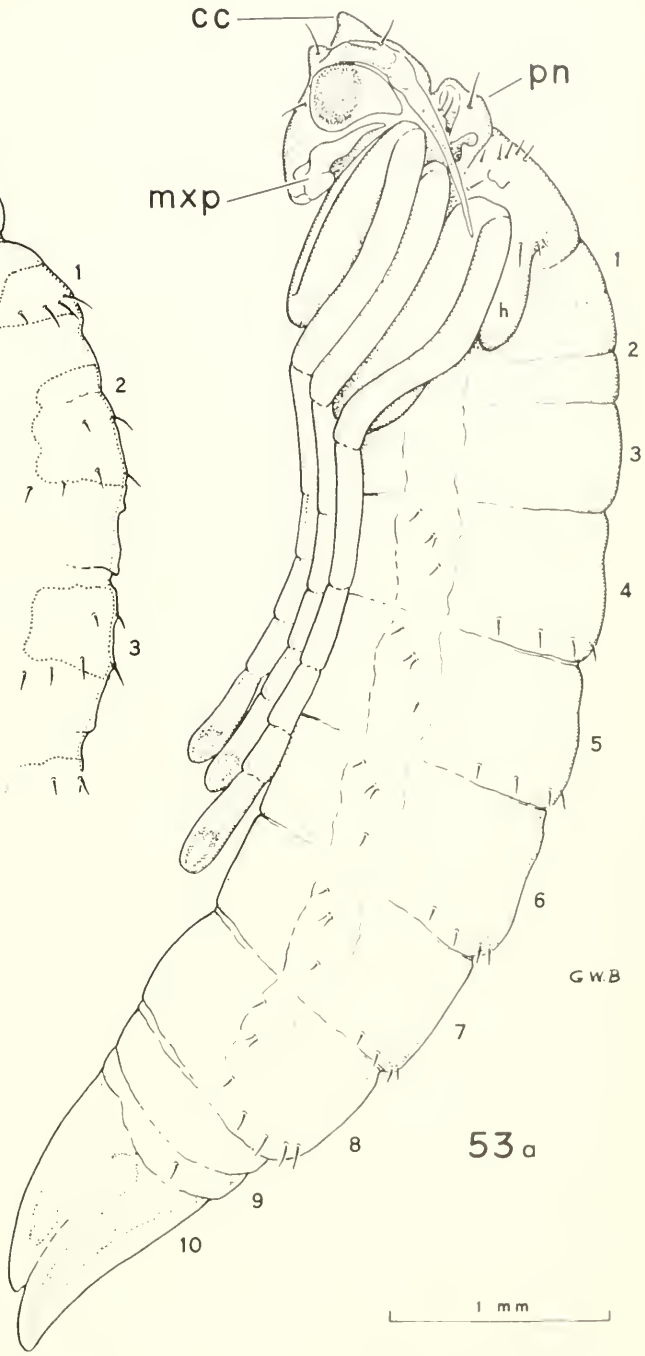
By attaining the adult stage in winter, *Chionea* escapes many of the common



52



53 b



53 a

FIGS. 52-53, pupae of *Chionea*. 52, anterior portion of pupa of *Chionea alexandriana* (from California), left lateral aspect, showing, by dashed line, position of transparent, empty wing sheath. 53, female pupa of *Chionea lutescens* (from Denmark), left lateral aspect; cc—cephalic crest, h—haltere, mxp—sheath of maxillary palp, pn—pronotum, numerals indicate abdominal segments. 53a, cauda of male pupa of *Chionea lutescens* (from Denmark), left lateral aspect, showing relationship of pupal cuticle to genital structures of enclosed pharate adult. Scale only approximate for Fig. 52.

warm-weather predators that take a heavy toll of winged crane flies, such as spiders, dragonflies, asilids and ants among the invertebrates, and frogs, toads, salamanders and many kinds of birds among the vertebrates. One would expect, however, that winter birds foraging on the snow must sometimes pick up these flies, for they probably appear as conspicuous to birds as to humans. Occasionally, also, a small mammal might consume an adult *Chionea* while hunting on the surface of the snow, although I imagine mice would find the flies more readily in their burrows and nests. The only observation of predation on *Chionea* known to me is that reported by Pritchard and Scholefield (1978). They found that *Chionea obtusa* was commonly preyed upon by *Grylloblatta campodeiformis* (Insecta: Grylloblattodea) in western Alberta, Canada. This was determined both by direct observation in laboratory terraria and by recovery of recognizable fragments of *Chionea* among the gut contents from 23 dissected specimens of *Grylloblatta*. As discussed earlier, mice must feed on adults of *Chionea* to perpetuate the life cycle of the *Hymenolepis*-like tapeworm.

Most kinds of Tipulidae are plagued by parasitic mites, which sometimes may become so numerous as to have a debilitating effect on the host. In contrast, Acarina are extremely rare on *Chionea*. In fact, I have seen only one infested fly—a male of *Chionea nivicola* from near Moscow, Idaho, collected on snow, 8 December 1961, by R. E. Stecker. In this fly there was no evidence of general weakness, but numerous blackened patches were noted on the membranous areas of the anterior sternal region of the abdomen, near where the mites were attached. Eight of the mites were clustered just behind the coxae of the hind legs, but one had its mouthparts embedded in the pleural membrane of the second abdominal segment. These mites have been identified by Dr. R. W. Strandtmann (pers. comm.) as belonging to the genus *Arctoseius* (family Ascidae). This mesostigmatid genus has been recorded from a few northern localities, its species in every case heretofore described as free-living, occurring in soil and litter. There is no question, however, that the mites described here were attached by their mouthparts to the fly.

IMMATURE FORMS OF CHIONEA

Eggs, larvae and pupae of *Chionea* have only rarely been found anywhere the genus occurs, either in Eurasia or North America. Although I have obtained eggs from two American species, and from these the first instar larvae, and have once found older larvae, I have failed in every attempt to rear the insects. Immature forms of some European species have been described briefly, but no details of the life history of any species have been made known.

Prof. Kenneth W. Cooper, who has described many aspects of the biology of *Boreus,* the winter mecopteran, is the only one who has reared a North American *Chionea*. He plans to publish a description of its life history.

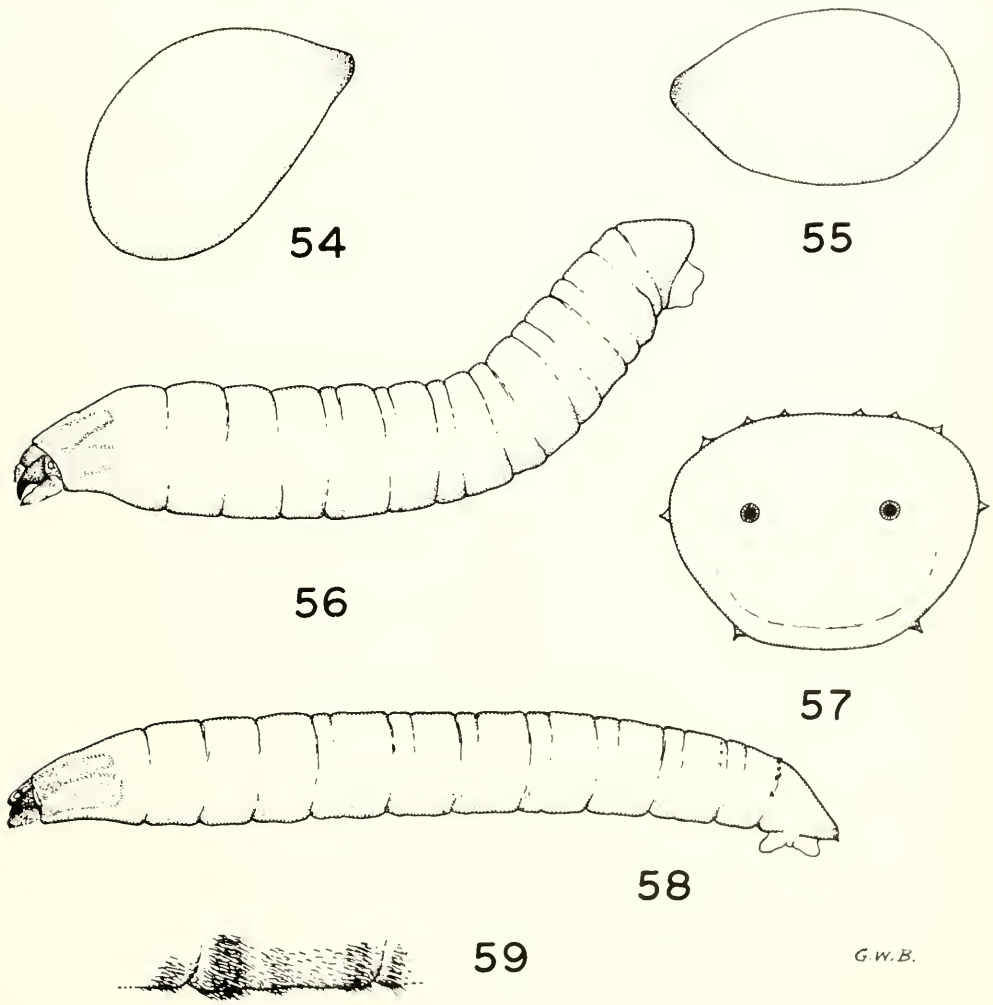
What follows concerning the immature forms of *Chionea* is offered to give at least a general impression of them.

Eggs

When laid, the eggs of *Chionea* are slightly elongate-ovoid, with an apparently white to pale buff color, which is imparted almost wholly by the contents, the chorion itself being hyaline, both transparent and glossy. The micropyle, or more exactly the microplyar area, is terminal, a little roughened, slightly protruding, fairly wide and sometimes pigmented (Figs. 54, 55). In the ovariole the egg is situated with the anterior or micropylar end away from the lumen of the ovary, and at the time of oviposition the more rounded posterior end of the egg proceeds first from the gonopore.

Although the largest eggs measured were from *Chionea valga*, a fairly large species, the smallest were obtained from *C. nivicola*, females of which have a greater average body size than those of *C. stoneana* producing slightly larger eggs. Dimensions of unlaid eggs of some representative species were *C. alexandriana*, 0.44 × 0.23 mm; *C. nivicola*, 0.43 × 0.22 mm; *C. scita*, 0.55 × 0.31 mm; *C. stoneana*, 0.45 × 0.27 mm; *C. valga*, 0.63 × 0.29 mm. Since egg size varies from one female to another in the same species and even somewhat among eggs of a single female, the above measurements actually are no more than averages for the particular individuals, yet they indicate the general size range for the genus.

During embryonic development there is a substantial increase in the dimensions of the egg, at least in those two species in which detailed observations of living eggs



FIGS. 54-59, egg and first instar larvae of *Chionea*. 54, egg of *Chionea stoneana*, lateral aspect; length 0.47 mm. 55, same, dorsal aspect. 56, *C. stoneana*, first instar larva; length 1.17 mm. 57, *Chionea scita*, spiracular disc of first instar larva, posterodorsal aspect. 58, *C. scita*, first instar larva; length approximately 1.2 mm. 59, *C. scita*, venter of typical abdominal segment, left lateral aspect, showing transverse bands of hairs (anterior at left).

were made. In *Chionea scita,* for example, the average dimensions increased from 0.55 × 0.31 mm to 0.63 × 0.36 mm, an increase of 15% in length and 16% in diameter. Probably the eggs take up moisture from their surroundings to bring about this change in size (cf. Torre-Bueno, 1920). To judge from the rapidity with which eggs of *Chionea* shrivel and collapse when separated from a moist substrate, the chorion must be readily permeable to water. Accompanying this increase in size is a change of color with age. Again, this seems to relate primarily to the darkening of the embryo as it takes on the characteristics of a larva, but there is also a slight increase in the faint yellowish or buff tinge of the chorion, tending toward pale amber-yellow, although the chorion retains its earlier transparency.

Duration of the egg stage was estimated by Brauer et al. (1854) as three weeks for the European *C. araneoides.* Under more or less natural conditions (outdoor rearing dish on a shaded widow-sill) in Michigan during late November and early December, when daytime temperatures fluctuated from 30-60°F, eggs of *Chionea scita* hatched after 15-18 days of incubation. Eggs of *C. stoneana* kept indoors but near a cold window-pane in January, in contrast, hatched after only eight days. Durbin (1975: 52) found that the incubation period in *C. carolus* varied from two to four weeks. From these scant data it would appear that the length of the egg stadium is, past a minimum time necessary for embryonic development, controlled largely by temperature and might be expected to fluctuate considerably in the natural environment, depending upon the winter weather of the year. Probably two to three weeks would be a reasonable estimate of the duration of this stage.

As the time of hatching draws near, the larva becomes increasingly active and may be seen moving within the egg. In *C. scita* this activity was noted during the last two or three days of the egg stadium. Since the chorion is transparent, the pigmented parts of the larva, such as eyes, mandibles, edges of cephalic sclerites and the like, and even the outlines of the rest of the body, are readily visible. The larva awaiting hatching rests most of the time but now and then may be seen "chasing its tail" around and around within the egg. As a result of this activity, the egg usually becomes rather shapeless just before hatching, changing form with the movements of the larva inside.

The number of eggs produced by one female varies according to the size of the individual (smaller females do not have proportionately smaller eggs) and probably also with the species. I have not dissected females of some species so cannot be sure of the latter. As mentioned earlier, a fully gravid female of *Chionea nivicola* contained 126 eggs, eight of them within the thorax (Fig. 48). A larger female of *C. alexandriana,* similarly bulging with eggs but without any crowded into the thorax, contained 194 and possibly had already laid a few when collected and preserved. A female of *C. scita* containing 132 eggs when collected had probably already laid some but still had a few within the thorax.

Just where the eggs are deposited in the natural habitat is not known, but possibly relevant observations were made of oviposition sites of two species in the laboratory. Both species were kept in covered rearing jars with moist paper tissue as the only substratum. *Chionea stoneana* females placed their eggs singly and always on the surface of the paper. Females of *C. scita,* however, almost invariably inserted their eggs singly into the paper tissue, usually just beneath the surface but in some cases to a depth greater than the length of an egg. Ordinarily the eggs were oriented with the anterior (micropylar) end upward. Twice I found an older egg (i.e., one that was expanded,

with larval structures visible within) deeply placed but with a smaller, pale egg above it in the same hole. Either the two were placed at the same time, the second in each instance infertile, or the female returned to the hole considerably later and deposited a second egg. Age differences among the eggs, times of hatching, and numbers of eggs laid in comparison to the number retained by the females in each case indicate that oviposition is not accomplished by the deposition of large numbers of eggs in two or three days or nights, as has been observed in some short-lived, summer crane flies, but that it is prolonged over many days, the period of oviposition probably somewhat proportional to the long life of the female fly. It appears that in general the eggs are placed singly, in no particular area of concentration, and that in nature the female deposits an egg here and another there as she moves about over the soil surface or other loose material in the burrow of a small mammal or other underground cavity in which she is at the time residing. Lugger (1896: 230) describing the oviposition probably of *C. stoneana* (as *C. valga*), reported that after mating on the snow surface the female crawled into a crevice in the snow and "penetrating to some depth into the snow, she deposited a number of elongated eggs, which, however, did not hatch." Although mating often does occur on the surface of the snow, I doubt that eggs are normally deposited in snow but rather on or in soil, near some source of larval food.

Larvae

What little can be offered here concerning the larvae of *Chionea* is based in part upon the description of the larva of the European *C. araneoides* by Brauer et al. (1854) but mostly upon my own observations of the larvae of two North American species, *C. scita* and *C. stoneana*. Any generalizations about the larvae made in the following discussion must accordingly be taken with these limitations in mind.

Larvae of *Chionea* in all instars are characterized by: 1) elongate, terete form, without conspicuous dorsal or lateral lobes on the abdominal segments; 2) spiracular disc without dorsal or ventral marginal lobes; 3) head capsule well sclerotized, with broad dorsal and lateral plates; 4) hypostomal ("mental") bars of head capsule widely separated medially; and 5) sharply pointed, many-toothed mandibles. This combination of characters will serve to distinguish larvae of *Chionea* from those of all other tipulid genera by use of the best available keys (Alexander, 1920; Alexander and Byers, 1981).

First Instar Larva.—Upon hatching from the egg, the young larva of *Chionea* is short, thick, and nearly transparent, with rather diffuse sclerotization evident in the head capsule. Only the orange-brown mandibles and blackish margins of the dorsal and lateral plates are apparently well sclerotized, the rest of the head being light gray to light grayish brown. The integument is sparsely covered with fine, grayish pubescence, but because it is so transparent the viscera are plainly visible. The brain and ganglia of the central nervous system, for example, are large and conspicuous, as is the gut, and the slender dorsal tracheal trunks can easily be made out. After a few hours of larval life, the head capsule darkens, and the body becomes more elongate and somewhat yellowish, yet it retains most of its transparency.

A newly hatched larva of *Chionea scita* measured 1.3 mm, or about twice the length of its egg just prior to hatching. This seems to be the usual ratio of body length to egg length at hatching. Growth is rapid, however, and four hours after hatching a larva of *C. stoneana* (Fig. 56) measured 1.17 mm, or 2.6 times the length of the egg just before emergence of the larva. The small relative size of the head capsule in the very young larva is notice-

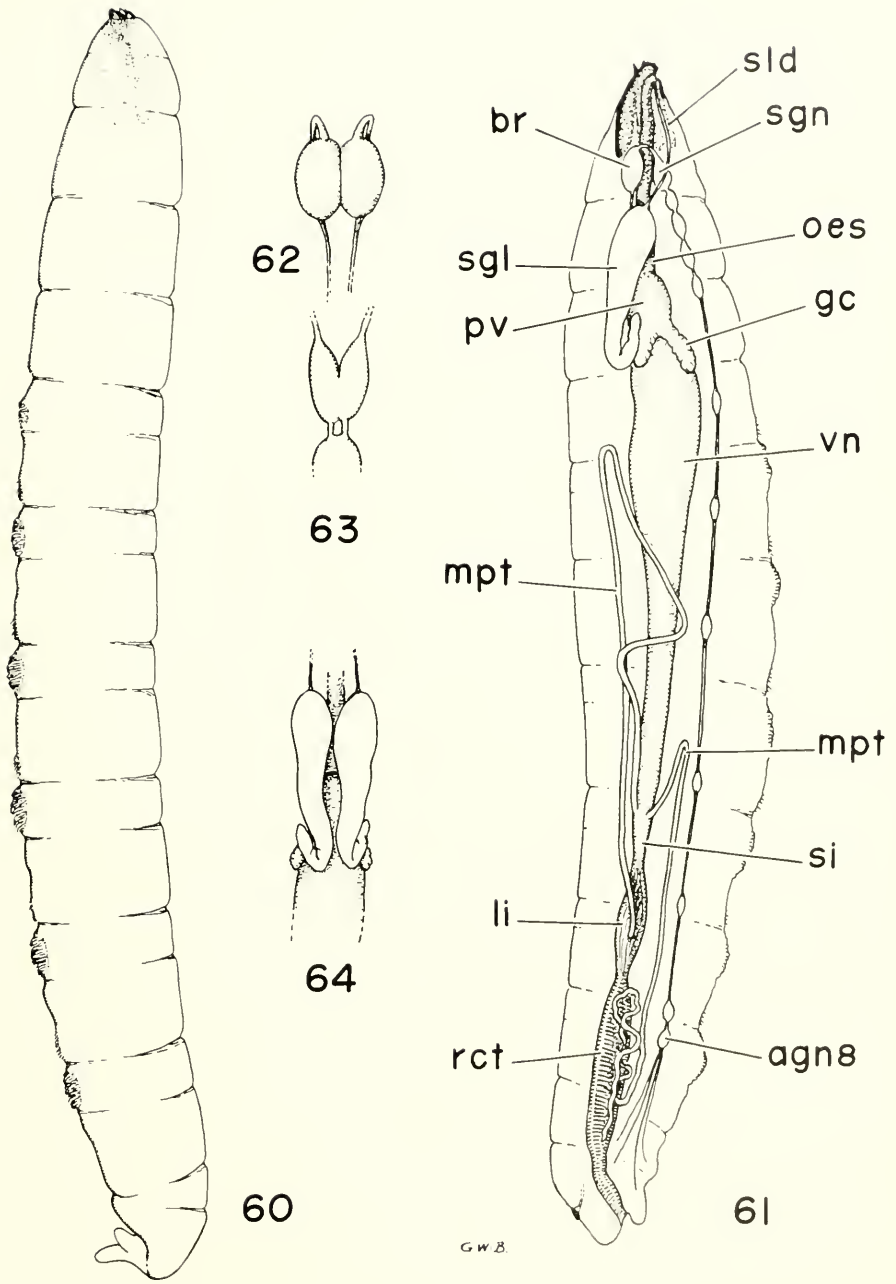
able. In a tipuline larva (*Dolichopeza;* see Byers, 1961*b*: 725, Fig. 79) two days old, the head capsule comprises about one-fourth of the total body length, but in a larva of *Chionea stoneana* of similar age it is only about one-seventh of the total length. The head structure of the first instar larva in general resembles that of an older larva, even the antennae and mouthparts being little different. The mandibles are more slender and the maxillae are somewhat more prominent. The integumental hairs in *C. stoneana* are very short and give the larva a roughened appearance, but those of *C. scita* are longer, especially ventrally (Fig. 59), and together with fine longitudinal plications in the skin itself impart to the larva a silky sheen in certain reflected lights. The caudal disc, or ninth abdominal tergum, of the young larva of *C. scita* (Fig. 57) is somewhat wider than long, shallowly impressed except around the edges, and bears two small, widely spaced spiracles. There are six minute, thorn-like projections arranged across the dorsal margin, the outermost ones slightly larger than the others, also two situated laterally and two ventrally. In the first instar larva of *C. stoneana,* the caudal disc is somewhat more deeply impressed, the spiracles slightly closer together, and the projections smaller, only the dorso-lateral and ventral pairs visible at the magnifications used.

During the final hours of the egg stage, when the larva is clearly visible through the chorion, the mandibles may be seen opening outward and closing inward and downward almost continuously, as if the larva were trying to bite its way out of the egg. It may be that some non-embryonic contents of the egg are ingested prior to hatching or that small fragments of the chorion are consumed during the larva's escape, for a few darkly colored particles may be seen within the gut of the larva as it is still emerging from its egg. The chorion, however, does not appear to be utilized even partially as the first larval meal, as in some other insects, but is left in a crumpled heap after the larva has emerged.

Young larvae of both *scita* and *stoneana* were not very active at temperatures from 36-52°F, but their activity increased with the rise in temperature within this span. They moved about to obtain food or to conceal themselves from light but at most other times lay still. Larvae of *C. scita* occasionally raised up with amazingly little of the posterior end of their bodies in contact with the moist paper substratum in their dish. In this position they were sometimes relatively motionless, at other times swayed slowly forward and backward

First instar larvae of *Chionea scita* were offered pulverized plant detritus for food but did not eat it. Since the mandibles were so sharp and the digestive tube so straight and without conspicuous caeca, unlike that of herbivorous tipulids, I thought the young larvae might be carnivorous. When I offered them a crushed podurid collembolan, they appeared to feed on it; however, the larvae died before growing noticeably, so I am unable to say what their diet was or should have been. Later observations on the diet of older larvae of *C. stoneana,* however, may be relevant and are discussed below.

Older Larva.—Two sizes of larvae of *Chionea stoneana* were collected from finely shredded material in an apparently abandoned mouse nest in eastern Kansas in January 1961. Despite their small size these are judged, on the basis of head capsule dimensions, to be the third and fourth instars. Six of the larger larvae average 5.8 mm in overall length and have a head width of 0.25 mm just behind the eyes; six of the smal'er ones have a mean length of 4.3 mm and a head width of 0.18 mm. Head length is apparently too variable to use in differentiating instars, possibly because of increase during a larval stadium.



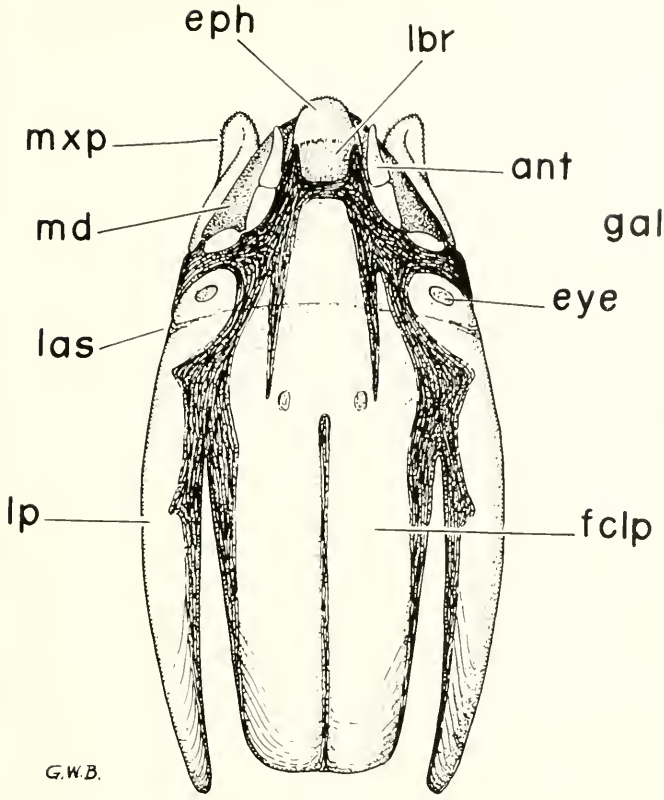
FIGS. 60-64, *Chionea stoneana*, larva. 60, larva (probably third instar), left lateral aspect; length about 5.9 mm. 61, internal anatomy of larva, right lateral aspect (skin cut on right side and partially outspread); agn8—eighth abdominal ganglion of ventral nerve cord (composite ganglion innervating posterior segments), br—brain, gc—gastric caecum, li—large intestine, mpt—malpighian tubule, oes—oesophagus, pv—proventriculus, rct—rectum, sgl—salivary gland, sgn—suboesophageal ganglion, si—small intestine, sld—salivary duct, vn—ventriculus. 62, brain, dorsal aspect. 63, suboesophageal ganglion and anterior half of prothoracic ganglion, ventral aspect. 64, salivary glands and portion of alimentary canal, dorsal aspect.

The ratio of growth from the smaller to the larger of these larvae, calculated from head width, is 1.4, and by application of this ratio, on the assumption that it is constant from one instar to the next, a head width of 0.13 mm can be calculated for the second instar. Further application of this "constant" yields a head width of 0.09 mm for the first instar, which is precisely that found by measurement. Accordingly, I consider the largest larvae found to be in the fourth stadium, and, because of their small size and the fact that some were preserved soon after molting, I would further conclude that they are in the early fourth stadium. If this conclusion is correct, considerable increase in body size during this stage would be required, for the largest larva in this group measured only 6.5 mm, and I would estimate a length of maturity of about 8 mm to yield an adult of 5 mm length, approximately the size in *stoneana*. In my study of *Dolichopeza* I found that there may be a 60% increase in larval length during the fourth stadium (Byers, 1961*b*: 747, Fig. 99); thus, a *Chionea* larva 6 mm long early in the fourth stage may well attain a length of 8 or 9 mm before pupation.

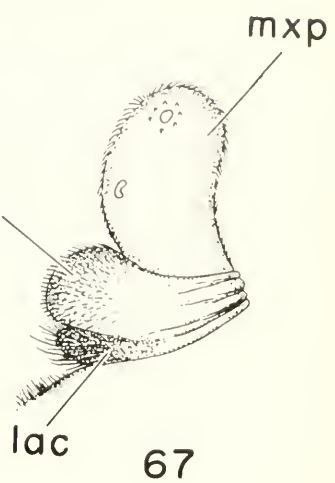
Third and fourth instar larvae are similar in appearance (Fig. 60), being elongate, nearly terete but slightly compressed, of approximately uniform thickness from the mesothoracic to seventh abdominal segment and tapered a little at each end. The body consists of a well sclerotized, almost completely retractile head, or head capsule, and three thoracic and ten abdominal segments. The prothoracic segment is weakly divided, its anterior ring concealed when the head is partially withdrawn. Both the mesothoracic and metathoracic segments, as well as the first abdominal, are undivided. Following these, each of the second through seventh abdominal segments is divided into a short anterior portion and a longer posterior annulus. The eighth segment is short and undivided. The tergum of the ninth or spiracular segment slopes steeply to the posterior end of the body; and situated on the underside of the wedge-shaped segment thus formed are the anal lobes, or "anal gills," which I believe represent the tenth or anal segment.

The integument is thin, soft, and densely covered with fine, yellow hairs, except on the pleural regions. Most of the hairs are so short as to be perhaps better described as pubescence, but on the venter they are longer, and on the lower surface of the anterior annulus of the second through seventh abdominal segments there is a transverse, slenderly elliptical patch of relatively long hairs that serves as a creeping welt. True creeping welts, however, are said by Alexander (1920: 795, in key) to be absent in the Tribe Eriopterini. On the dorsum, the longer hairs form narrow, transverse, poorly defined ridges, one on each undivided segment and two on the divided abdominal segments. A similar ridge appears ventrally on the posterior ring of each abdominal segment, recalling the pattern seen in the first instar of *C. scita* (Fig. 59). As the larva is turned while being observed under bright light, the fine, appressed integumental hairs present a silky sheen and straw-yellow color, and the pleural surfaces give an iridescent reflection. There are no setae or hairs of any greater size than those of the abdominal venter already described.

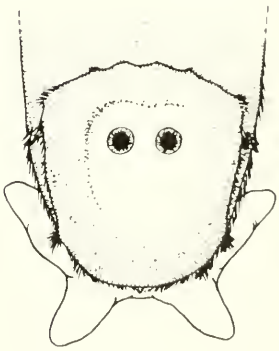
The spiracular disc is concave in the middle (Fig. 68) in the living larva and in most preserved specimens, but treatment of a larva with hot water for preservation may obliterate this depression. There are no conspicuous lobes surrounding the disc, yet one or two pairs of slight protuberances can be made out along its dorsal edge. Elsewhere about the perimeter are hairs, which form small tufts laterally at the level of the spiracles and ventro-laterally. The spiracles are circular with black centers. In *C. stoneana* there is no pig-



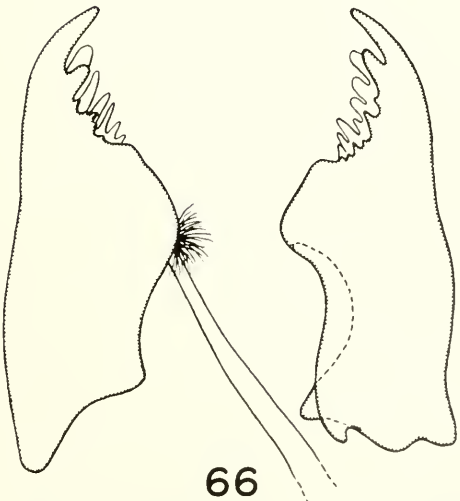
65



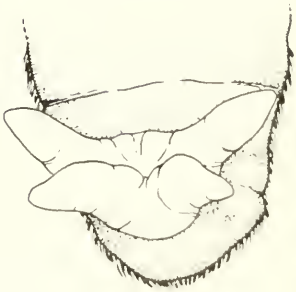
67



68



66



69

FIGS. 65-69, *Chionea stoneana*, details of larva. 65, head capsule, dorsal aspect; length 0.54 mm; ant—antenna, eph—epipharynx, fclp—frontoclypeus, las—line of attachment of skin, lbr—labrum, lp—lateral plate, md—mandible, mxp—maxillary palp. 66, mandibles, ventrolateral aspect of each (asymmetry due only in part to slight difference in position); length of right mandible, pictured at left, 0.093 mm. 67, left maxilla, ventral aspect; gal—galea, lac—lacinia, mxp—maxillary palp. 68, spiracular disc of fourth instar larva, posterodorsal aspect. 69, anal lobes, or "gills," of fourth instar larva, ventral and slightly lateral aspect.

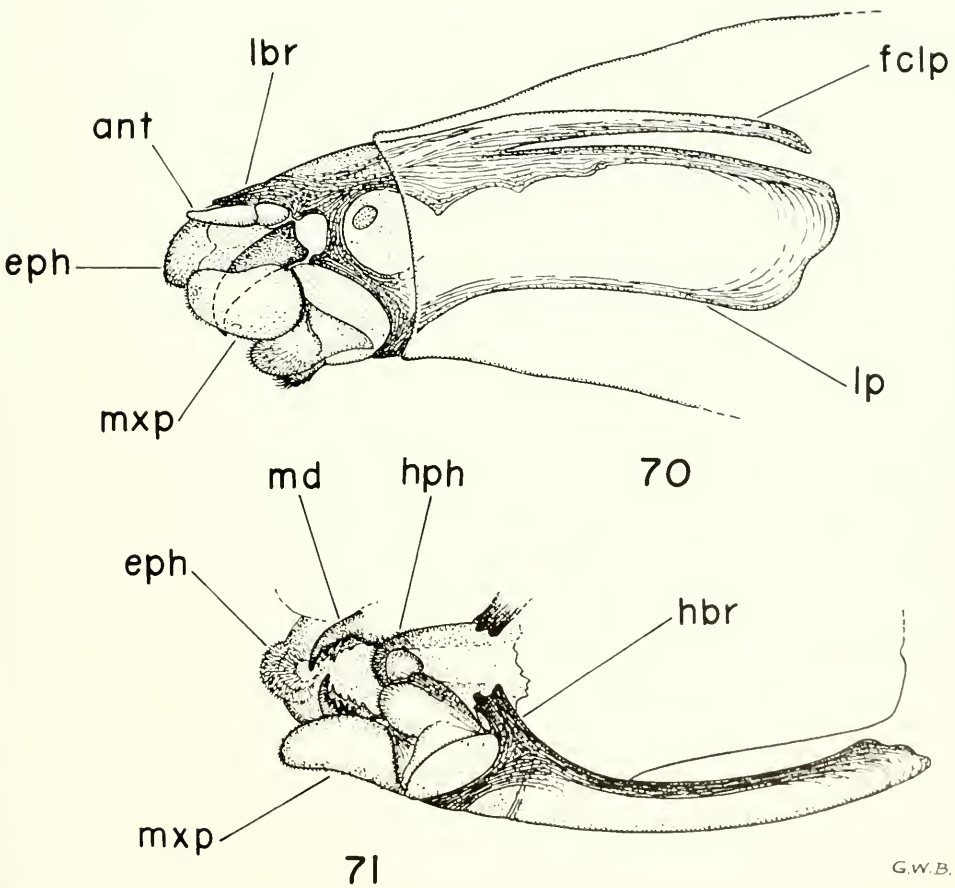
mentation above or between the spiracles, such as is found in the European *C. araneoides* (see Alexander, 1920: 952, Fig. 447) and *C. lutescens*. There are four retractable, subhyaline anal lobes (Fig. 69), the anterior pair somewhat longer than the posterior pair. It seems unlikely that these serve any respiratory function, so I would not apply the term "anal gills" to them. They may, however, aid in locomotion and may be withdrawn when the larva is quiescent.

Head and Mouthparts.—The resemblance of the larval head of *Chionea* to that of *Cladura* illustrated and described by Alexander (1922) is striking and gives strong support to the supposition of close relationship between these two genera based on the adult flies. At the same time, the head capsule in *Chionea* is unlike that of most other eriopterine genera (e.g., *Erioptera, Molophilus, Ormosia, Gonomyia*) in that it is extensively sclerotized. In place of slender bars or rods extending backward from the anterior region of the head, as in the typical eriopterine, *Chionea* has broad dorsal and lateral plates (Fig. 65), much like those seen in larvae of the Limoniini. The large dorsal plate (epicranial plate) I regard as the fronto-clypeus (Byers, 1961*b*: 734). Apparently formed from two areas of sclerotization, it has a median, blackened line of fusion of the two plates and is notched at the middle of its truncate posterior end but is not otherwise divided. The lateral margins of the fronto-clypeus are blackened and recall the strongly sclerotized, blade-like extensions of the lateral plates seen alongside the fronto-clypeus in some tipuline larvae. The lateral plates are slightly bowed outward but are not deeply concavo-convex. Their dorsal and ventral margins have a similar curvature and are more or less parallel, the posterior end of each plate being irregularly truncate. There is evidence that both the fronto-clypeal and lateral plates may elongate by accretion during a larval stadium and that the lateral plates may grow more rapidly than the dorsal one, but I have not made any comparative measurements on particular individuals to substantiate this.

There is a strong, rigid fusion of the fronto-clypeus with the lateral plates at each side for about one-third the length of the entire head capsule, but the lateral plates are not connected ventrally. The space between their lower margins is approximately oval, broadly open behind but partially closed anteriorly by the hypostomal bars. There is no hypostomal bridge (or "mentum," as it has been called), that is, no median sclerotization; the bars merely extend far enough to provide for the lower articulation of the maxilla, then terminate in a slightly widened, indistinctly toothed tip. The labrum (Fig. 65) is fused posteriorly with the fronto-clypeus and produced anteriorly into two darkly sclerotized points that project over the sides of the epipharynx. The epipharynx is rounded anteriorly, curved downward and narrowed ventrally, and is coarsely pubescent. Lying alongside the labrum and above the bases of the mandibles are the antennae, each consisting of a sub-cylindrical, apparently immovable basal segment and an elongate, conical terminal segment.

Each mandible is hinged along a rather short base, articulating dorsally with the strongly sclerotized clypeal region of the head just below the antennal base and laterally with a conspicuously projecting, blackened condyle close above the maxilla (Fig. 70). As the dorsal points of articulation are closer together than the lateral ones, the movement of the jaws is downward and inward, upward and outward, the tips touching or nearly so at full closure but not overlapping. The mandibles (Fig. 66) are sharply pointed, densely sclerotized, and blackened basally, with two rows of denticles on the mesal surface of the apical one-third of their length.

Some of the denticles are acutely tipped, others rounded, and the larger ones appear somewhat flattened and blade-like. Near its mid-length the mandible bears a bulbous mesal enlargement, within which the tendon of the mandibular adductor muscle is attached and on which a tuft of hairs (brustia) is situated. This enlargement possibly serves as a molar surface for grinding food, but there is no evidence so indicating, either in the nature of the surface itself or in the larval diet as far as it is known. In fact, the sharp tips and double rows of denticles on the mandibles suggest that the larva of *Chionea* may be carnivorous, certainly that it is not a typical herbivorous tipulid. There is considerable variation in the shape of the mandibles, as shown by Figure 66 which compares both mandibles of the same individual. Part of the evident difference in the basal portions of these two mandibles is due to slight rotation of one from the position of the other. Below the mandibles and largely concealing them in ventral aspect are the maxillae, which have a membranous attachment to the anterior margins of the lateral plates and to the hypostomal



Figs. 70, 71, *Chionea stoneana,* head capsule of larva (probably third instar); length of head 0.54 mm. 70, left lateral aspect, showing anterior part of membranous cuticle attached; ant—antenna, eph—epipharynx, fclp—frontoclypeus, lbr—labrum, lp—lateral plate, mxp—maxillary palp. 71, ventral aspect (most of left half omitted); eph—epipharynx, hbr—hypostomal bridge, hph—hypopharynx, md—mandible, mxp—maxillary palp.

bars. The maxillae are large, fleshy (i.e., thick but lightly sclerotized), trilobed, and covered with minute pubescence (Fig. 67). The more dorsal lobe is the palp and has at its apex what appears to be a sensory apparatus, and the narrow, sclerotic band around its base is possibly the rudimentary stipes. The smaller, lower lobes very likely represent the galea and lacinia, and the sclerotized band traversing their common base may be all that remains of the cardo.

Ventrally, the mouth cavity is bounded primarily by the lower lobes of the maxillae (Fig. 71) and is closed medially by the combined hypopharynx and labium. The hypopharynx itself is well sclerotized and is connected laterally to the inner ends of the hypostomal bars. It is pilose on its dorsal surface, which slopes downward to a rounded anterior margin.

Near the anterior end of each lateral plate and behind the mandibular attachment, there is a subcircular clear area in the plate, bordered above, before, and below by intense sclerotization. In the living larva and in some preserved specimens, a dark spot may be seen beneath this clear area. This pigmented spot is the eye, which in life has the characteristic purple color and which can be moved about slightly beneath its cuticular covering.

Alexander (1920: 952, Fig. 445) drew attention to a peculiar structure on the dorsal surface of the head capsule illustrated by Brauer et al. (1854: Fig. 5). He interpreted this as a pair of "appendages which are toothed on the outer face" and concluded that "these probably represent part of the mentum, but from Brauer's figures they would appear to lie above the labrum." Brauer's illustration is confusing in certain respects but seems to me to be purely a dorsal view, the structures in question probably being the two halves of the fronto-clypeus.

Internal Anatomy.—Only the larva of *Chionea stoneana* was explored internally, so comparisons with other species are not possible at this time, except for a few minor comparisons with Brauer's figures of *C. araneoides* (Brauer et al., 1854: Figs. 3, 4). The larva illustrated (Fig. 61) was immersed in hot water, which resulted in its outstretched condition. In a living larva most of the organs are more contracted, thus are wider and not so linearly arranged.

Digestive system: The most conspicous structures inside the larva are those comprising the digestive tube (oesophagus, proventriculus, ventriculus, and intestine) and organs associated with it (salivary glands and Malpighian tubules). The oesophagus is a relatively straight, muscular tube of narrow diameter, leading from the mouth to the anterior end of the short, thick-walled proventriculus. Above and beside the proventriculus and oesophagus lie the two salivary glands (Figs. 61, 64), which have a large lumen; they are widest anteriorly, tapering and recurved cephalad posteriorly, with thin walls, formed of large, flattened, polygonal cells containing nuclei of such great diameter that they can easily be seen with the dissecting microscope at 130× magnification. In most of the larvae dissected the salivary glands were large and distended, and I have never seen salivary glands of such comparatively great size in any other crane fly larva. At each side of the anterior end of the ventriculus there are two elongate gastric caeca. These are twice as long in some individuals as in others, their length possibly varying with physiological activity, for in those specimens having the longer caeca there was a greater amount of food in the ventriculus.

More than 40% of the length of the digestive tube is the ventriculus which is muscular and relatively smooth-walled, its anterior half approximately three times the diameter of the posterior half. There are four Malpighian tubules attached two at either side of what appears to be the

posterior end of the ventriculus, although they are anatomically behind the proctodeal valve. Sometimes these tubules appear to be arranged randomly in the haemocoel, but one or two may have their distal ends closely applied to the wall of the rectum, supposedly to facilitate the excretory function by fairly direct transport of recovered water. The small intestine and large intestine are poorly delimited, short and thin-walled as contrasted with the ventriculus. Notably absent from the hind gut is the intestinal caecum, which is conspicuous in all herbivorous tipulid larvae I have investigated. The rectum is longer than the rest of the hind gut and of greater diameter; it appears somewhat striated because of small bands of muscle in its nearly membranous walls.

Tracheal system: The dorsal tracheal trunks are of surprisingly small diameter (Fig. 72), which may relate to the rate of metabolic activity of the larva. Since the distribution of branch tracheae and other parts of the respiratory system in *Chionea* follows rather closely that described for *Dolichopeza* (Byers, 1961*b*; 740-741, Fig. 82), I have not illustrated the tracheal system in Figure 61 and will not describe it in detail here.

Central nervous system: Lying in the prothoracic segment just behind the head capsule and above the oesophagus is the brain (Figs. 61, 62). It consists of two broadly joined ellipsoidal lobes, each giving off a circumoesophageal connective anteriorly and a more slender posteroventral branch leading to the viscera. The suboesophageal ganglion is made up of two spindle-shaped bodies joined at the mid-line for somewhat over half their length (Fig. 63). Each of these receives a circumoesophageal connective at its anterior end and is joined posteriorly by a short length of the nerve cord to the first thoracic ganglion. All three thoracic ganglia lie generally in the floor of the larval mesothorax. The eight abdominal ganglia

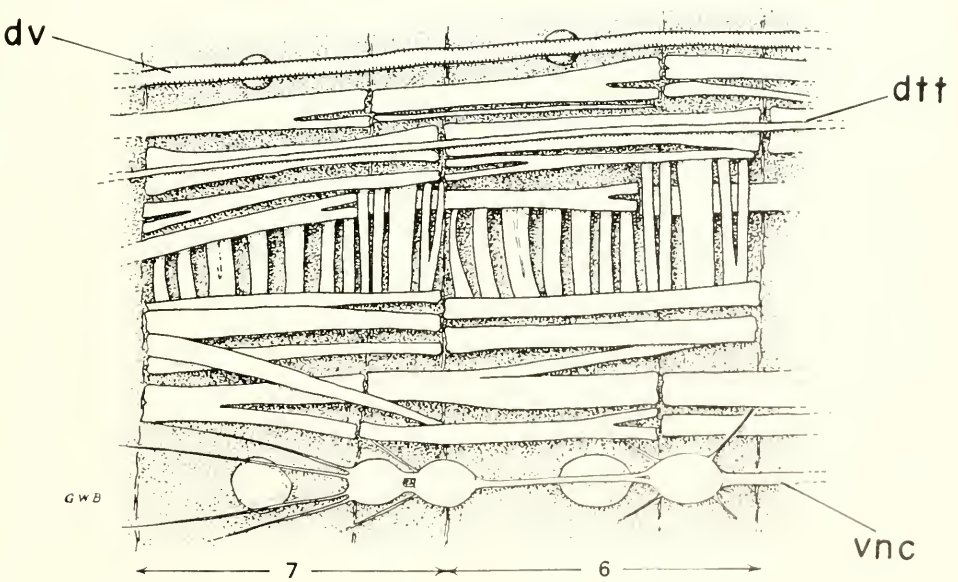


Fig. 72, peripheral musculature, nervous, circulatory and respiratory structures in sixth and seventh abdominal segments of larva of *Chionea stoneana*, interior aspect; approximately half of each segment shown, from near mid-dorsal line above to near mid-ventral line, anterior at right, extent of segments indicated by numbered arrows at bottom of drawing; abdominal ganglia 6-8 shown; dtt—dorsal tracheal trunk, dv—dorsal vessel, vnv—ventral nerve cord.

are arranged from metathorax to seventh abdominal segment, as shown in Figure 61.

Muscular system: Figure 72 will give some impression of the complexity of number and arrangement of the muscles of the body wall in two representative segments of a fourth instar larva. These muscles were not studied in detail. Their functions can be inferred from their points of attachment. Longitudinal muscles, both intersegmental and intrasegmental, are concerned largely with locomotion. Both vertical and longitudinal muscles occur in the pleural region and probably function both in locomotion and in deformation of the segments for other purposes, such as displacement of haemolymph.

In Figure 72 it may be noticed that beneath the nerve cord, near mid-length of each segment, there is a circular or subcircular structure. A similar but smaller disc occurs in the dorsum of each abdominal segment, above the dorsal vessel. These whitish, flattened structures, closely applied to the body wall, are of unknown function; they are not to be confused with histoblasts of legs and wings that may be seen in the thorax of crane fly larvae. Their gross anatomy suggests they may be glandular.

Pupae

The pupae of only two North American species of *Chionea* have been found, but none has yet been described. As mentioned earlier, K. W. Cooper will describe the immature forms of *C. valga*. In October 1975, David Durbin found one male and two female pupae in hard, compact soil in rearing dishes in which adult Chioneas had been kept 8-9 months earlier (Durbin, pers. comm.). The species could not be determined with certainty but was probably *C. alexandriana* Garrett. Mr. Durbin kindly permitted me to examine two of these pupae in order that I might compare them with pupae of *C. lutescens* Lundström, a European species. Edwards (1936: 89) briefly described pupae of *C. lutescens* from Denmark and compared them with the description of the pupa of *Cladura* by Alexander (1922). I have examined these pupae (Byers, 1961*a*) and in the following paragraphs compare them with Durbin's specimens from California.

Since the overall dimensions of the pupa bear a fairly direct relationship to the size of the developing adult within, one would expect the pupae to show variation in size similar to that seen among adults. Moreover, since in the pupal instar the body is not greatly contracted, or telescoped, the pupa may be expected to be somewhat longer than the adult. The pupae of both *Chionea lutescens* and *C. alexandriana* are about 6-7 mm in length as preserved in alcohol. Their color late in the pupal stadium is light brown, the pupal skin itself nearly hyaline and the pupal color largely that of the developing imago. There is probably considerable darkening of the body of the enclosed adult during the day or so just prior to its emergence, producing a corresponding apparent color change in the pupa with only slight darkening of the pupal skin.

Head.—The cephalic crest (Fig. 53, cc) is prominent, arching forward to a narrowly rounded apex, then descending abruptly on its anterior surface. It is shallowly grooved along the dorsal mid-line and bears a large seta posteriorly at each side. Over the basal segment of each antenna there is a rounded lobe with a seta near its apex. The part of the antennal sheath enclosing the pedicel is roughly cylindrical, then there is a slight enlargement of the sheath to accommodate the fusion segment, and thereafter it tapers evenly to the tip. Edwards (1936) expressed surprise at the length of the antennal sheaths but overlooked the fact that the flagellomeres have unusually long verticils. Sometimes the distal end of the antennal sheath lies alongside the anterior or middle tibia instead of in the position

illustrated, but the proximal portion is close above the pupal eye. Rounded above and below and somewhat flattened mesally, the pupal eye has a broadly triangular, lateral prolongation that extends well beyond the adult eye developing beneath it. Such a prolongation occurs in pupae of several eriopterine species. It is considerably wider in *Chionea* than in the closely related *Cladura* (cf. Alexander, 1922: Fig. 7). Near the mesal margin of each pupal eye is a seta, apparently on the frons, although the frons, clypeus and labrum are joined without evident sutures. The sheaths of the maxillary palps and labellar lobes of the labium are distinct, those of the palps being more or less straight and lying alongside the anterior margins of the sheaths of the front legs.

Thorax.—Absence of evident wing sheaths and respiratory horns is the most conspicuous aspect of the thorax (Fig. 53). Actually, however, there are flattened, closely appressed, wholly transparent—and of course empty—wing sheaths, approximately overlying the metathoracic femur and tibia, as indicated by a dashed line in Figure 52. I am indebted to David Durbin and Kenneth Cooper for pointing this out, for I had overlooked these structures on the pupae of *C. lutescens* (Byers, 1961*a*). Nevertheless, I believe that the reference by Edwards (1936: 89) to "small wing sheaths" in that European species must pertain to the sheaths of the halteres, for the surprising fact about those of the wings is that they are of what might be called full size, that is, proportionately as large as in the fully winged *Cladura*. It is something of a puzzle why they have persisted at all when other evidence suggests that the essentially apterous condition of the adults is an ancient one. The sheaths of the halteres are closely applied anteriorly to the sheaths of the hind legs and mesally to the first abdominal segment.

Wood (1952: 106) similarly found no great difference in size of wing sheaths between subapterous and fully winged species of South African *Longurio*.

In view of the close similarity of the pupae of *Chionea* and *Cladura* (Alexander, 1922) in other features, the absence of thoracic respiratory horns in *Chionea* is not too surprising. In their place are a pair of small, narrow, curved pits, one at either side on the anterior mesonotum (i.e., in front of the pseudosutures). These incisions should not be confused with the pit-like depressions at either side of the pronotum. Setae are distributed on the pronotum, mesonotum, and bases of the sheaths of the halteres approximately as illustrated in Figures 52 and 53. Their lengths and positions vary between species and somewhat from one individual to the next within a species.

The leg sheaths are situated generally as shown (Fig. 53), although their arrangement varies in detail. There appears to be considerable contraction of the femora and tibiae within their respective sheaths which are relatively short, extending backward only to the second abdominal segment. The femoral sheaths are folded, somewhat basad from mid-length, thereby providing some additional space for development of these conspicuously elongate segments. This can be most easily seen in the prothoracic legs, viewed from below. In contrast to the short leg sheaths, those of the tarsal segments, except the basitarsi, have a length rather close to that of the corresponding segments in the emerged adult, and there seems to be comparatively little contraction in the tarsi prior to emergence. The sheaths of the front and middle legs extend to about the posterior margin of the fifth abdominal segment, those of the hind legs to the posterior edge of the sixth abdominal segment. Toward the end of the pupal stadium the tarsi are readily visible within their sheaths and are partially rotated so that their dorsal surfaces are directed laterally with respect to the body of the pupa.

Abdomen.—The first abdominal segment is short and undivided as in the larva. In a young pupa (Fig. 53) only the second segment has a fairly distinct, short anterior ring and a longer posterior one, the third through seventh segments being very weakly divided, although the constrictions between segments are distinct. By the time the adult insect is well formed and its cuticle has separated from the pupal cuticle (the pharate condition), the pupal segmentation is almost obliterated but is indicated by the visible adult sclerites (Fig. 52). While abdominal spiracles are not evident on the pupa (Fig. 53), those of the developing adult eventually become clearly visible through the pupal cuticle (Fig. 52). In the female both the tenth segment and the cerci are contained within the tergal sheaths of the ovipositor, while the sternal sheaths, continuous with the sternal region of the eighth segment, enclose the hypovalves of the developing adult. In the male (Fig. 53a) there is an indistinct constriction near mid-length of the ninth abdominal segment which can, as the adult body separates from the pupal skin, be seen to correspond to the division between the basal portion of the segment and the styles, particularly the basistyles. The dististyles are formed within thick, wrinkled or striated, irregularly tapering sheaths that curve upward at the extreme end of the pupa. When the adult body is almost fully formed, the genitalial structures, which earlier had become distinctly separated from their sheaths, do not nearly fill them, but the rest of the imaginal abdomen remains tightly pressed against the pupal skin.

The distribution of setae on the pupal abdomen varies with species as indicated in Figures 52 and 53. Near the posterior edge of the third through seventh terga there is a transverse row of eight short setae. One or two pairs may be present in a more anterior transverse row on these terga, or there may be no others. The pleural regions are only slightly raised, with four minute setae arranged as in the figures, occurring at each side on the second through seventh segments. On the posterolateral eighth or anterior ninth segment there is a single short bristle at each side. All these setae are much less prominent than their counterparts in the pupa of *Cladura flavoferruginea,* and certain of the setae found in that species are lacking in *Chionea*. There are no setae on the sterna in either males or females.

Usually the pupa frees itself of the last larval skin, but Kryger (see Edwards, 1936: 90) found one pupa of *C. lutescens* with the larval skin still attached.

KEY TO MALES OF NORTH AMERICAN *Chionea*

1. Body color light yellowish brown; antennae with 9 or more flagellomeres (sometimes 8 in *albertensis*) including fusion segment 2
   Body color brown, reddish brown, gray or black; antennae with 7 or fewer flagellomeres (rarely 8 in *obtusa*) 5
2. Posterior margin of ninth abdominal tergum entire, without setiferous lobes and not notched (Fig. 99) 3
   Posterior margin of ninth abdominal tergum with 2 setiferous lobes and an intervening U-shaped or V-shaped, pale, membranous area (notch in tergal margin) (Figs. 75, 231) 4
3. Dististyles spatulate, broadly rounded at apex, concave on mesal surface (Fig. 222); abdominal terga with median spot and darkened lateral margins ..... *wilsoni,* new species
   Dististyles not spatulate, pointed at apex, of about same diameter throughout, beyond base (Fig. 99); abdominal terga without distinct color pattern ..... *scita* Walker

4. Gonapophyses in dorsal aspect narrowing gradually toward posterior apex (Fig. 75); setae of body and legs acuminate, hair-like; notch between lobes of ninth abdominal tergum broadly to narrowly V-shaped (Figs. 75, 80) *albertensis* Alexander

   Gonapophyses in dorsal aspect broad just before posterior apex, narrowing abruptly (Fig. 231); setae of body and legs thick, black, spine-like, those of hind legs with elevated bases (Fig. 230); notch between tergal lobes broadly U-shaped *macnabeana* Alexander

5. Gonapophyses slender, upturned and hook-like at apex (Figs. 157, 188, 195, 214) 6

   Gonapophyses without slender, hook-like apex (Figs. 107, 117); small subapical tooth (Fig. 176) may be present 11

6. Dististyles with dorsal, pilose concavity on apical half (Fig. 186) *excavata*, new species

   Dististyles without dorsal, pilose concavity 7

7. Gonapophyses bowed outward from base to near mid-length, then converging slightly in apical half, apices again divergent (Figs. 165, 204); antennae with 4 or 5 flagellomeres, including fusion segment 8

   Gonapophyses not bowed outward, their inner borders in dorsal aspect only slightly diverging; antennae usually with 3, rarely 2 or 4, flagellomeres 9

8. Dististyles each with blackened ventral tooth; gonapophyses each with semicircular dorsal flange directed dorsolaterad; ninth abdominal tergum with shallow median emargination bordered by setiferous lobes (Fig. 204) *lyrata*, new species

   Dististyle without ventral tooth; gonapophysis without dorsolateral flange; ninth tergum with deep, U-shaped emargination and without lobes (Fig. 165) *carolus* Byers

9. Body color generally black; sclerites with velvety texture, membranous areas dark gray (Fig. 214) *nigra*, new species

   Body color generally brown; sclerites smooth except for hairs, membranous areas light brown 10

10. Abdominal terga darkened anteriorly and along mid-line, producing evident pattern; tergal hairs scattered over tergum, especially on posterior half; space between gonapophyses (dorsal aspect) usually narrowly U-shaped (Fig. 156) *alexandriana* Garrett

    Abdominal terga unicolorous or nearly so; tergal hairs short, sparse, concentrated along posterior edges of terga; space between gonapophyses widest at base, narrowed near mid-length of gonapophyses (Fig. 193) *jellisoni*, new species

11. Antennae with only 2 or 3 flagellomeres; gonapophyses elongate, narrow, with sides of each subparallel or slightly converging 12

    Antennae usually with 5 or 6 flagellomeres; gonapophyses broad or deep, blade-like, with one or both sides of each conspicuously curved and convergent toward apex 14

12. Posterior margin of ninth abdominal tergum appearing entire (dorsal aspect) or broadly and evenly emarginate (posterodorsal aspect); gonapophyses in dorsal aspect broad, concave on upper surface, with convergent apices (Fig. 110); antennae usually with only 2 flagellomeres; body color light brown to brown *hybrida*, new species

Posterior margin of ninth abdominal tergum narrowly emarginate, with projecting, setiferous lobes bordering emargination; gonapophyses in dorsal aspect elongate, narrow, with subparallel sides; antennae usually with 3 flagellomeres . 13

13. Body coloration dark brown and light brown, with evident pattern on abdominal terga (Fig. 172); gonapophyses with small subapical tooth on dorsal margin, apices slightly convergent (Fig. 176) .... *durbini,* new species

Body coloration dark gray, without pattern on abdominal terga; gonapophyses without subapical tooth on dorsal margin, apices not convergent (Fig. 129) .... *stoneana* Alexander

14. Thoracic dorsum humped, anterior slope of mesonotum steep (Fig. 139); posterior margin of ninth abdominal tergum appearing entire (dorsal aspect) or broadly and evenly emarginate (posterodorsal aspect), without setiferous lobes (Fig. 141) ..... *valga* Harris

Anterior slope of mesonotum gradual (Fig. 123); posterior margin of ninth abdominal tergum with broadly V-shaped emargination and low, broad lobes or narrow lobes bordering emargination 15

15. Gonapophyses in form of vertical plates, divergent at base (Fig. 89), convergent apically; posterior margin of ninth abdominal tergum with narrow, prominent lobes bordering emargination (Fig. 88) .... *nivicola* Doane

Gonapophyses each a broad, horizontal plate concealing vertical keel (Fig. 117); posterior margin of ninth abdominal tergum with low, broad lobes bordering emargination (Fig. 118) ..... *obtusa,* new species

KEY TO FEMALES OF NORTH AMERICAN *Chionea*

1. Body coloration light yellowish brown; antennae with more than 8 flagellomeres 2

Body coloration brown, reddish brown, gray or black; antennae with fewer than 8 flagellomeres 5

2. Ninth abdominal sternum not interrupted medially, either with acute median angle and elongate, moderately sclerotized areas at either side of its mid-line (Fig. 82) or with subtriangular, moderately sclerotized median structure protruding ventrally (Fig. 228); arms of genital furca bowed inward or nearly straight, forming V-shaped figure 3

Ninth abdominal sternum interrupted medially, with subtriangular, moderately sclerotized area at either side of mid-line (Figs. 85, 105); arms of genital furca bowed outward, making U-shaped figure .. 4

3. Ninth abdominal sternum forming acute median angle (Fig. 82); western species ..... *albertensis* Alexander

Ninth abdominal sternum forming subtriangular median structure that protrudes slightly ventrally (Fig. 228); species of southeastern U. S. ..... *wilsoni,* new species

4. Stout black setae along posterior margins of sixth and especially seventh abdominal terga, thicker than sternal setae (Fig. 84); slightly sclerotized expansion at each side of eighth abdominal tergum; western coastal species .... *macnabeana* Alexander

Setae on abdominal terga 6 and 7 about as thick as those of corresponding sterna, not conspicuously blackened (Fig. 104); eighth abdominal tergum of about uniform

length throughout; species of eastern United States ..... *scita* Walker

5. Anterior femora slender at base, expanded toward mid-length and thick in apical half (Fig. 168); ninth abdominal sternum interrupted medially, each arm slightly bifurcate at apex and expanded subapically (Fig. 170) .... *carolus* Byers

Anterior femora not conspicuously thickened in apical half; ninth abdominal sternum if interrupted medially (*stoneana, valga*) without apical bifurcation or subapical expansion 6

6. Antennae with 5 or more flagellomeres (4-6 beyond fusion segment) 7

Antennae with 4 or fewer flagellomeres (1-3 beyond fusion segment) 11

7. Cerci long, slender, about 8-9 times their greatest width in lateral aspect 8

Cerci shorter, about 5-6 times their greatest width in lateral aspect 9

8. Hypovalves approximately 2.5-3 times as long (measured from notch to tip) as their greatest width (Fig. 147); mesonotum abruptly downcurved to pronotum (Fig. 140); arms of genital furca thick (Fig. 148); species chiefly of eastern United States and Canada ..... *valga* Harris

Hypovalves approximately 4 times as long as their greatest width (Fig. 95); mesonotum not abruptly downcurved to pronotum; arms of genital furca slender (Fig. 96); species of northwestern United States and southwestern Canada .... *nivicola* Doane

9. Cerci obtusely rounded at tip; eighth abdominal tergum expanded at sides (Fig. 125); apex of ninth sternum recurved ventrad (Fig. 126) ..... *obtusa*, new species

Cerci acutely tipped; eighth abdominal tergum not expanded at sides, of about uniform length throughout (Figs. 189, 211); apex of ninth sternum a backward-projecting point 10

10. Hypovalves with ventral margin strongly curved upward, dorsal margin nearly straight (Fig. 189); median plate of ninth abdominal sternum not distinctly attached laterally to arms of sternum (Fig. 190) ..... *excavata*, new species

Hypovalves with dorsal and ventral margins about equally curved toward apex (Fig. 211); median plate of ninth abdominal sternum clearly attached laterally to arms of sternum (Fig. 212) .... *lyrata*, new species

11. Eighth abdominal tergum expanded at sides to approximately half length of seventh tergum (Fig. 112); antennae usually with single flagellomere beyond fusion segment ..... *hybrida*, new species

Eighth abdominal tergum not expanded at sides, much less than half length of seventh tergum throughout; antennae usually with 2 or more flagellomeres beyond fusion segment (rarely only 1) 12

12. Cerci widest beyond mid-length, ventral margin abruptly upturned to apex (Fig. 135); ninth sternum narrowly interrupted medially, its arms nearly converging on dorsal surface of rounded, membranous median lobe (Figs. 134, 136) .... *stoneana* Alexander

Cerci widest near base, narrowing more or less evenly toward apex; ninth sternum sclerotized medially (but see *durbini*, Fig. 180), without membranous median lobe 13

13. Cerci long, slender, 7-9 times their greatest width in lateral aspect, or about twice as long as terga 9-10 together (Figs. 160, 179); hypovalves 3-3.5 times as long as their greatest width 14

Cerci only 4-6 times their greatest width in lateral aspect, or 1.2-1.6 times length of terga 9-10 together (Figs. 189, 199, 216); hypovalves only about twice as long as their greatest width 15

14. Ninth abdominal sternum with a tridentate, darkly sclerotized median plate (Figs. 161, 162); abdominal terga darkened along anterior margin and medially ..... *alexandriana* Garrett

Ninth abdominal sternum only lightly sclerotized medially, without posterior teeth (Fig. 180); abdominal terga darkened along posterior margin and medially, with hairs arising from darkly pigmented spots ..... *durbini,* new species

15. Median plate of ninth abdominal sternum narrowly triangular, not distinctly attached at sides to arms of sternum (Fig. 190) ..... *excavata,* new species

Median plate of ninth abdominal sternum wider than long, distinctly attached at sides to arms of sternum (Figs. 200, 217) 16

16. Median plate of ninth abdominal sternum with 3 low, rounded lobes its central area less darkly sclerotized than outer borders (Fig. 200); cerci flattened, appearing much wider in dorsal aspect than in lateral aspect (Figs. 197, 199); overall body color light brown to brown ..... *jellisoni,* new species

Median plate of ninth abdominal sternum with straight posterior margin, or slightly lengthened near mid-line, evenly darkened (Fig. 217); cerci not flattened; overall body color black to dark brown ..... *nigra,* new species

THE C. scita GROUP

General body color yellowish, light yellowish brown, or brown; antennae of 8-12 segments (scape, pedicel, fusion segment and 5-9 additional flagellomeres); male gonapophyses blade-like, more or less vertically oriented (compressed), without upturned apical hook; dististyles usually with dorsomesal lobe; eighth abdominal tergum of female short throughout or expanded laterally to more than half length of seventh tergum; cerci and hypovalves long, slender. Included species: *C. albertensis, C. macnabeana, C. nivicola, C. scita,* and *C. wilsoni,* new species.

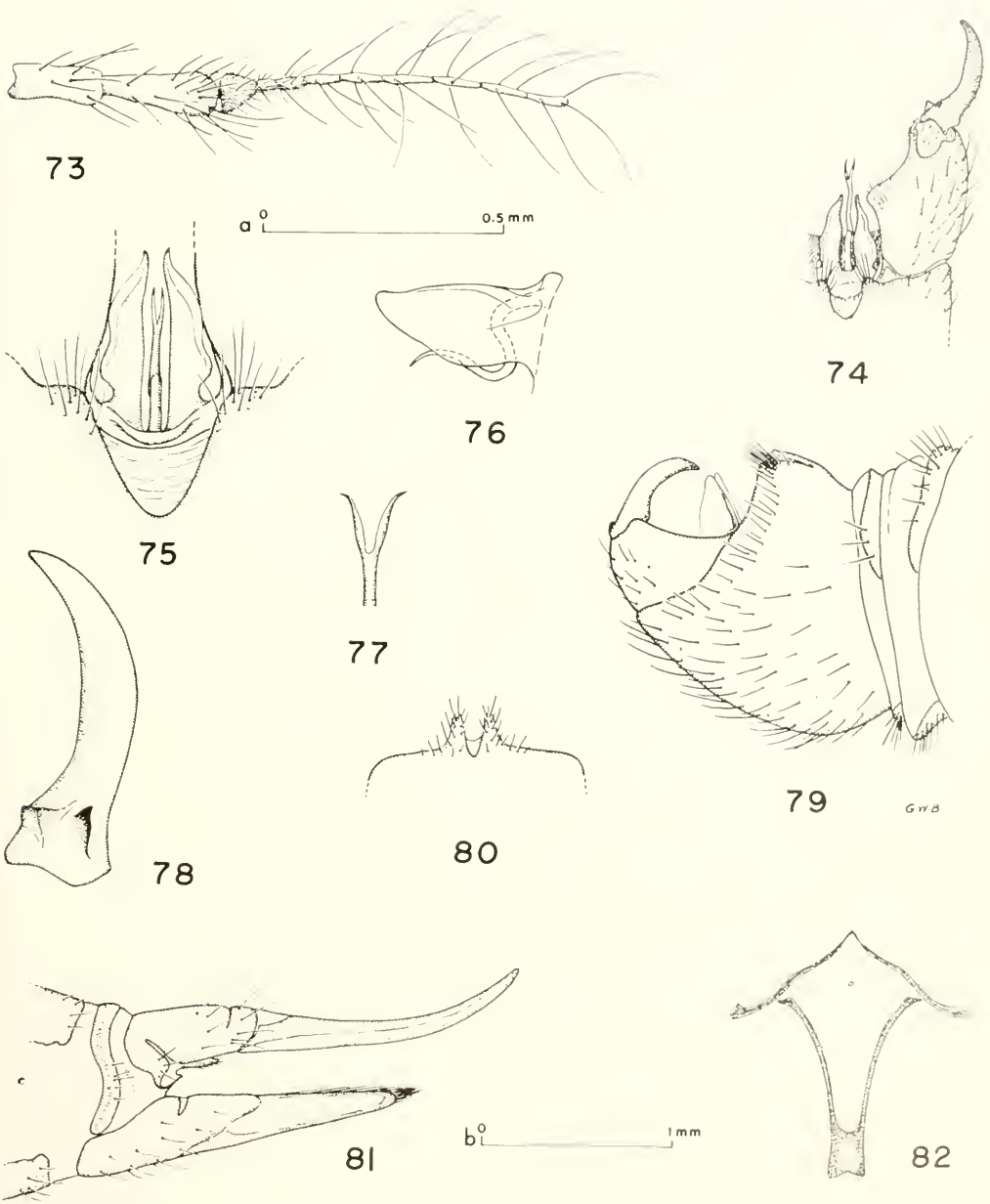
Chionea albertensis ALEXANDER

Chionea albertensis Alexander, 1941: 211-212; Alexander, 1965: 72.

Diagnosis.—A western montane species, yellowish to yellowish brown in color, with antennae of 10-11 segments; male gonapophyses blade-like, acute at apex in dorsal aspect; female cerci very long and slender, ninth sternum acutely pointed at convergence of two narrow bands, each bordering an indistinct, sclerotized area.

Description.—General appearance: Head dark yellowish brown, thorax yellowish brown; legs long, yellowish; abdominal terga dull yellowish brown, slightly darker brown laterally and faintly so along midline; sterna dull yellowish brown; ninth segment of male dark yellowish brown to reddish brown, cerci of female light amber-yellow; pleural membranes pale yellowish brown. Length of male about 5-9 mm, female about 6-7 mm, exclusive of antennae.

Head: Antennae (Fig. 73) consisting of short subcylindrical scape, about three times as long as its diameter, club-shaped pedicel approximately 25% longer than



Figs. 73-82, *Chionea albertensis*. 73, right antenna of female, lateral aspect. 74, gonapophyses, penis, left basistyle and dististyle, and part of ninth tergum of male from British Columbia, dorsal aspect. 75, gonapophyses and penis, dorsal aspect (tenth segment pushed inward). 76, same, right lateral aspect. 77, apex of penis, dorsal aspect. 78, right dististyle, ventromesal aspect. 79, terminal abdominal segments, male from Oregon, right lateral aspect, to show upturned position of gonapophyses. 80, ninth tergum, male from Idaho, dorsal aspect, showing narrow lobes separated by narrow cleft. 81, terminal abdominal segments, female from British Columbia, left lateral aspect. 82, ninth sternum and genital furca, female, ventral aspect. Scales: a—73, 75, 76, 78, 82; b—74, 79-81.

scape, and eight or nine flagellar segments; fusion segment asymmetrically subconical, only a little longer than greatest diameter; first one or two segments beyond it short, subcylindrical, with much shorter hairs than on more distal flagellomeres; other flagellomeres elongate, each bearing an irregularly spaced verticil of three hairs. Vertex dark yellowish brown with brownish or grayish pruinosity and sparse but long black setae, sometimes with an indistinct brownish median stripe or elongate spot. Eyes with about 100-120 ommatidia each.

Thorax: Halteres pale dull yellowish brown but not contrasting conspicuously with color of thoracic dorsum. Legs long (hind femora about three-fourths as long as total body length in normally extended specimens), yellowish brown; basitarsi yellowish brown, except brown to dark brown at apex; succeeding tarsomeres brown to blackish brown; claws very long, slender. Setae of legs black, longest on tibiae; usually seven (4 dorsal, 3 ventral) rows of femoral setae, males sometimes with additional small setae not in rows. Approximately 12 long, black setae in each of two poorly defined rows on mesothoracic dorsum; sparse, shorter setae on pronotum and on pleuron above middle coxa; several on each coxa.

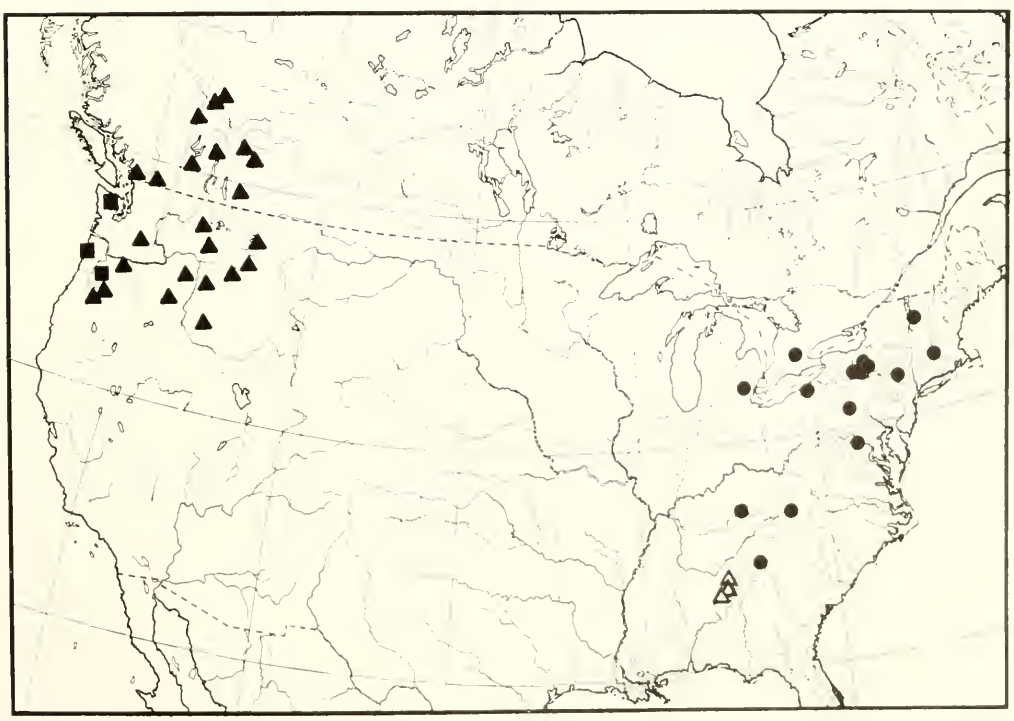
Abdomen of male: Posterodorsal edge of ninth tergum (Figs. 74, 80) with a V-shaped to U-shaped median emargination, usually deeper than wide, at each side of which is a small, thick lobe bearing 6-15 dark brown setae. Gonapophyses (Figs. 75, 76) blade-like, thick at base but abruptly compressed to thin, roughly triangular blades, acutely rounded at apex, almost vertically oriented in apical half, ventral edges a little closer together than dorsal edges; space between gonapophyses, seen from above, almost parallel-sided; apex of penis flared outward, produced into two acuminate points (Fig. 77). Basistyles elongate, only moderately thick for genus; posteromesal lobes pilose, simply rounded. Dististyles (Fig. 78) dark yellowish brown, usually smoothly curved and acutely tipped; mesal tooth near base of dististyle prominent, somewhat wedge-shaped with rounded to subacute apical edge, strongly sclerotized; ventral tooth well developed though not projecting conspicuously in most specimens, usually acute and black at tip, less often blunt. Tenth segment pale yellowish gray, not abruptly narrowed near mid-length but broader at base than at apex. Anterior terga bearing long, black setae along caudal margins, smaller setae laterally, sternal setae more slender, not as blackened, longest and most numerous at posterolateral corners.

Abdomen of female: Eighth tergum short (i.e., slender) throughout, yellowish brown, with an indistinct, transverse, reddish brown stripe running its entire width. Hypovalves of eighth sternum long, slender, tapering evenly toward narrowly rounded apex (Fig. 81). Arms of genital furca of about equal thickness throughout, evenly curved outward to attachment with ninth sternum (Fig. 82); basal portion longer than wide, not darkly sclerotized except at lateral margins. Ninth sternum (Fig. 82) formed by two narrow, darkly sclerotized bands converging at an acute point; integument immediately posterior to each band lightly sclerotized except near mid-line; in some females, junction not as strongly or extensively sclerotized as rest of bands. Cerci long, slender, about 8-9 times as long as greatest width, evenly curved both dorsally and ventrally, with acute tips, about 1.4 times as long as hypovalves measured from notch to tip. Sixth and seventh terga with scattered slender, brownish setae; sternal setae sparse.

Types.—Holotype, male, Banff, Alberta, with no additional data. The specimen is damaged, the body broken and only two legs remaining; the genitalia have been cut off and mounted in balsam on a

square of celluloid attached to the pin, and although this method of preservation has in many cases proved unsatisfactory, the details of the hypopygium can still be made out readily. The holotype is in the United States National Museum, Washington, D.C. Two legs and one antenna from the holotype are mounted on a microscope slide in the collection of Dr. C. P. Alexander, now in the U.S. National Museum.

Variation.—In some individuals, the apical end of the fusion segment is narrowed to the diameter of the adjoining flagellar segment and may give the appearance of an additional segment. This part may actually become articulated with the fusion segment, producing two similar, short-cylindrical segments without verticils before the rest of the flagellum. In fact, I have seen two males from Cranbrook, British Columbia, in which one antenna has one more flagellomere than the other. Eight segments beyond the fusion segment seems to be the more common condition, occurring in about three-fourths of the specimens examined. The setae of the head, thorax, legs and abdomen, although often long, thick, dark and therefore conspicuous, do not occur in any fixed pattern, and even those on a particular sclerite may vary greatly in size and number from one individual to the next. All parts of the hypopygium of the male are variable, notably the dististyles, which in the holotype are a little shorter, thicker and less evenly curved than in most other males seen. Also, the basistyles in the holotype are shorter and more stout than in an average male of the species. In a male from Clearwater County, Idaho, the lobes of the ninth tergum are prominent, considerably longer than wide, and the median emargination is quite narrow (Fig. 80). This same male is the only one seen lacking the blackened



Map 1. Ranges of *Chionea albertensis* (solid triangles), *C. macnabeana* (squares), *C. scita* (circles) and *C. wilsoni* (open triangles). Each symbol represents one or more collections within a county (in the United States) or at a locality.

ventral tooth on the dististyles. A large, robust male from northeastern Oregon has the basistyles depressed somewhat into the ninth sternum, the gonapophyses correspondingly appearing turned upward (Fig. 79).

Relationships.—Several characters, including body coloration, antennal structure, and form of the ovipositor and ninth sternum of the female, as well as the gonapophyses of the male, point to the relationship of *Chionea albertensis* with *C. macnabeana* Alexander in the western mountains and *C. scita* Walker and *C. wilsoni,* new species, in eastern North America. The female of *albertensis* is smaller than that of *macnabeana* and has fewer antennal segments (10 or 11, as compared to 12 in *macnabeana*) and less conspicuous setae on the posterior abdominal terga. The scape and pedicel of the antenna in *albertensis* are more slender than their counterparts in *macnabeana* and the pedicel longer. Both species appear to have the genital furca of similar shape except for the illustrated difference in curvature of the arms, which may be an artifact of preservation. Differentiation of males of *albertensis* from those of *scita* is an easy matter. The obvious character is the ninth tergum, emarginate medially, with setiferous lobes bordering the emargination in *albertensis,* but entire (very broadly indented in posterodorsal aspect) in *scita.* The apex of the penis in *albertensis* is bifurcate with two slender points, but in *scita* it is somewhat spoon-like. The surface of the gonapophyses in males of *albertensis* is more undulating and the apex more acute than in *scita.* Ordinarily, also, the number of antennal segments in *albertensis* is one less than in *scita,* and *scita* does not appear to be as long-legged as *albertensis.* These last named characters apply to females as well as males. Females of *albertensis* may be distinguished from those of *scita* also by the ninth sternum and the number of antennal segments, and in *albertensis* the bursa copulatrix is long and curved, not looped as in *scita.*

The recently discovered male of *C. macnabeana* agrees with the relationships described on the basis of the females.

Geographic Distribution.—Present collection records show that *Chionea albertensis* occurs from mountainous eastern British Columbia and western Alberta southeastward along the Bitterroot Range and nearby mountains into Idaho and western Montana, also southward to northeastern Oregon and westward to southwestern British Columbia (Map 1).

Seasonal Distribution.—Although most specimens have been taken in November, there are records for late August, mid-October, January, February, and mid-March, the last in Cranbrook, British Columbia, the only locality in which several individuals have been collected. I anticipate that further and especially concentrated local collecting will yield a clear picture of two generations a year.

Habitats.—About all that can be said of the habitats of *albertensis* is that it occurs in forested, generally mountainous areas within the described geographic range. Even this comes only from my own observations of the collecting areas, made primarily in summer. As far as I am aware, all known specimens were taken on the surface of snow; unfortunately, detailed ecological data are available for only a few of them.

Collection Records.—ALBERTA: Banff, no other data (holotype); Banff National Park, Boulder Pass, 7490 ft, on 12 in of snow, 14 Oct. 1968, K. W. Richards (1 ♀); Jasper National Park, 7600 ft, 18 Aug.-1 Sept. 1970, P. Kuchar (1 ♂, 1 ♀). BRITISH COLUMBIA: Cranbrook (49° 31′N, 115°46′W), elevation about 3000 ft, on snow, 16 March (1 ♂), 1 Nov. (1 ♀), 2 Nov. (1 ♂), 4 Nov. (1 ♂, 2 ♀), 15 Nov. (1 ♂, 2 ♀), all collected by C. B. D. Garrett, no years recorded; Goldstream River, 52°45′N, 118°45′W, 26 Dec. 1979, J. G.

Woods (6♂, 5♀); Mt. Revelstoke National Park, 28 Dec. 1976, J. G. Woods (1♀); Wells Gray Provincial Park (about 50°30′N, 120°00′W), along willow flats, Stillwater, 1 Jan. 1962, P. Joslin (1♂); Manning Prov. Park, Lightning Creek, on snow at dusk, about 0°C, 4000 ft, 9 Feb. 1980, R. J. Cannings (1♀); same but Similkameen River, 4000 ft, 11 Feb. 1978, S. G. Cannings (1♀); same but Chowanten Creek, about 0°C, overcast, 4000 ft, 17 Feb. 1980 (1♀); Vancouver, Hollyburn Mountain, 16 Feb. 1980, L. Vasington (1♀); Silver Star Mt. (15 mi NE of Vernon), light snow, –3°C, 29 Jan. 1981, A. Bryan (1♀). IDAHO: Benewah Co., Crystal Creek, on snow, 22 Dec. 1968, M. M. Furniss (1♂); Boise Co., 11 mi N of Idaho City, on snow in pine forest, 30 Nov. 1974, G. A. Shook (1♂); Clearwater Co., 8 mi N of Elk River, 19 Nov. 1961, E. H. Dustman (1♂); Clearwater Co., E Fork of Potlatch River, 5.5 mi E of Bovill, on snow, 11 Dec. 1978, R. C. Biggam, T. F. Hansen and P. C. Schroeder (1♂, 2♀); Idaho Co., Clearwater National Forest, Mud Creek Jct., 25 Nov. 1978, R. C. Biggam and M. A. Maurer (1♂, 1♀); Idaho Co., Warm Springs Creek, about 20 mi SW of Lolo Pass on U.S. Hwy. 12, 28 Dec. 1975, A. Greene (2♀). MONTANA: Lake Co., vicinity of Univ. of Montana Biological Station, from oil-formalin-alcohol traps, in snow, 24 Dec. 1972 (2♂, 5♀), 6 Jan. 1973 (2♂, 3♀), 21 Jan. 1973 (2♂, 1♀), 23 Jan. 1973 (1♀), 12 Feb. 1973 (2♂), 17 Feb. 1973 (2♂, 3♀), all collected by D. S. Potter; Missoula Co., Lolo vicinity, Bitterroot Mountains, about 6000 ft, on fresh snow, Nov. 1950, J. A. Chapman (1♂); Missoula Co., Elk Creek, Lubrecht Forest, 4000 ft, 22 Jan. 1972, R. A. Haick (2♀); Grant Creek, GC-3, 13 Feb. 1972, R. A. Haick (2♂). OREGON: Grant Co., Anthony Lakes Ski Area, on snow, 18 Feb. 1974, K. Goeden (1♂); Lane Co., Pengra Pass, 5100 ft, 22 mi SE of Oakridge, 4 Jan. 1975, J. Lattin (1♂); Linn Co., Santiam Pass, 2 mi N of Santiam Hwy., 2:30 P.M., on snow, 30 Dec. 1977, J. D. Lattin (1♀); Wallowa Co., Wallowa-Whitman National Forest, Eagle Cap Wilderness Area, 6000-7000 ft, weather clear, 24 Nov. 1972, A. Greene (1♂); Wasco Co., 15 mi SE of Government Camp, Frog Lake Butte, 31 Dec. 1975, P. J. Johnson (1♂, 1♀). WASHINGTON: Spokane Co., Mt. Spokane State Park, 5000 ft, 9 Nov. 1975, A. Greene (1♂); Yakima Co., 5-6 mi E of Chinook Pass, on snow about 2.5 ft deep, 17 Dec. 1977, P. J. Johnson (1♀); 15 mi E of Chinook Pass, on snow about 2.5 ft deep, 17 Dec. 1977, P. J. Johnson (1♂); Yakima Co., Sand Lake, 2 mi N of White Pass, Snoqualmie National Forest, 5295 ft, walking on snow 30-45 cm deep, in coniferous forest, 25 Nov. 1979, W. Kaltenthaler (1♂).

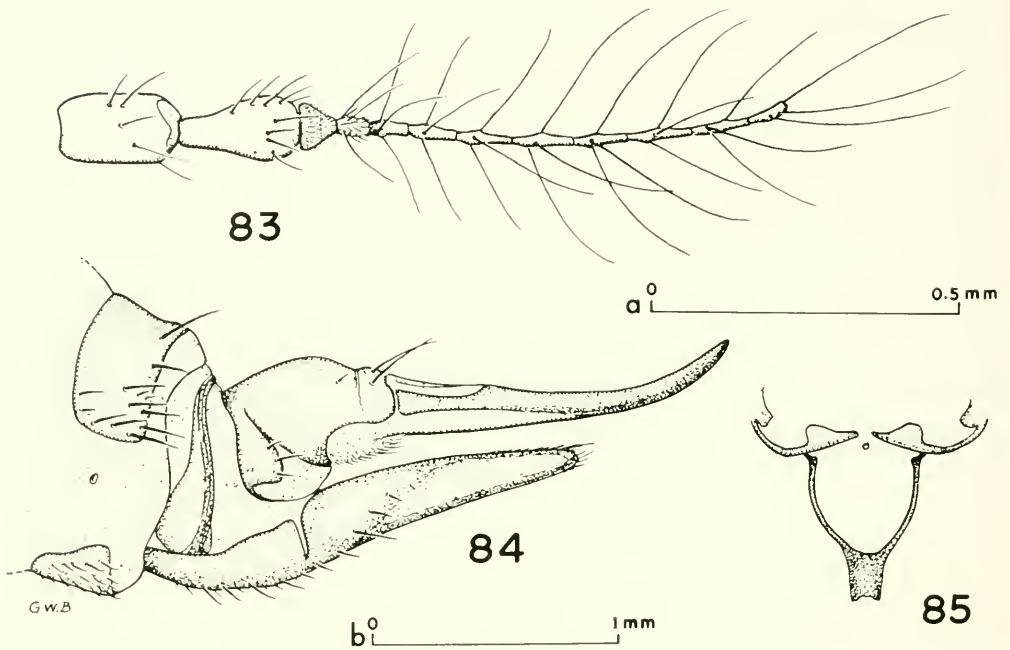
Chionea macnabeana Alexander

Chionea macnabeana Alexander, 1946: 156; Alexander, 1954: 69; Alexander, 1965: 72.

Diagnosis.—A large west coast species of yellowish brown color, with antennae of 12 segments, scape and pedicel thick; female cerci very long and slender; sixth and seventh abdominal terga bearing several thick, blackened spines, especially on posterolateral corners; male gonapophyses appearing broadly rounded with inner apical point, in dorsal aspect.

Description.—General appearance: Head, thorax, legs and abdomen yellowish brown to light brown, head slightly darker than thorax; sclerites not much darker than membranous areas; cerci of female long, amber colored, palest at base. Length of female, exclusive of antennae, about 8.2-9.4 mm.

Head: Antennae (Fig. 83) consisting of thick, subcylindrical scape, short, club-shaped pedicel, and ten flagellomeres; fusion segment short-conical, or turbinate, shorter than its basal diameter, partially



FIGS. 83-85. *Chionea macnabeana*. 83, antenna of female holotype (from slide in C. P. Alexander collection). 84, terminal abdominal segments, female from Washington, left lateral aspect. 85, ninth sternum and genital furca, female, ventral aspect. Scales: a—83, 85; b—84.

subdivided in one specimen seen; first flagellomere beyond it short, cylindrical, bearing many short, fine hairs in addition to verticil of three hairs which are shorter than those of succeeding flagellomeres. Antennal length about 1.5 mm. Setae of vertex stout, long, black. Eyes with about 200 ommatidia each.

Thorax: Halteres tan, not contrasting conspicuously with color of thoracic dorsum. Legs slender (femora not incrassate), yellowish brown, tarsi only a little darker brown. Setae of legs long, stout, black; those in dorsal rows slightly larger and thicker than ventral setae. Setae of coxae, thoracic dorsum, and sternal sclerites stout, black.

Abdomen of male: See Appendix 2.

Abdomen of female: Eighth tergum short (i.e., slender) dorsally with lightly sclerotized anterior expansion at each side (Fig. 84), posterior margin more darkly sclerotized. Hypovalves of eighth sternum long, slender, evenly tapered toward narrowly rounded apex. Ninth tergum with three short setae near posterolateral margin on each side; tenth tergum mostly bare with two setae on each side near posterior margin. Tenth tergum somewhat humped upward near mid-length, and anteriorly its sides extended and curved ventrad. Arms of genital furca of approximately uniform thickness throughout, smoothly curved outward to points of attachment on ninth sternum; basal portion a little longer than wide, most strongly sclerotized at sides. Ninth sternum (Fig. 85) formed by two slender, well sclerotized bands with expanded tips which almost meet medially. Cerci long, slender, about eight times as long as greatest width, evenly curved both dorsally and ventrally to acute tips, noticeably longer than hypovalves (about 1.17 times as long as hypovalves measured from notch to tip). Sixth and seventh terga with thick, blackened setae along posterolateral margins, most conspicuous on seventh tergum; sternal setae

blackened but generally shorter and more slender than those on dorsum.

Types.—Holotype, female, Wilson River, Tillamook Co., Oregon, elevation 2125 ft, 8 February 1946, James A. Macnab collector. The type is mounted on a microscope slide in the collection of C. P. Alexander, Amherst, Massachusetts (transferred in 1981 to the U.S. National Museum, Washington, D.C.).

Relationships.—That *Chionea macnabeana* belongs to the *scita* group is indicated by the pale body, the relatively large number of antennal segments, and the similarity in structure of the female genital segments between this species and *C. albertensis* and particularly *C. scita*. A discussion of the relationships of *macnabeana* and *albertensis* will be found under the heading of the latter species. The most useful differences for separating these two western species are the greater number of flagellomeres and shorter, thicker scape and pedicel in *macnabeana* and the presence of thick, black setae on the sixth and seventh abdominal terga, where in females of *albertensis* the setae are more slender, not as darkly colored, and more sparsely distributed. Females of *macnabeana* and *scita*, both of which may have 12 antennal segments, may be differentiated by the detailed structure of the genital furca and ninth sternum. The furca in *scita* is somewhat more lyriform and the ninth sternum interrupted at the mid-line, with a longitudinal bar at each side of the break (Fig. 94). Also, as pointed out by Alexander (1946: 156, as *primitiva*), females of *scita* are on the average smaller, with "more delicate vestiture" on the legs.

Geographic Distribution.—For 25 years this species was known only from the type locality in northwestern Oregon. The second known specimen was collected 30 December 1971, about a mile east of the eastern end of Lake Crescent, Clallam Co., Olympic Peninsula, Washington, between 900 and 1300 ft (277-400 m), by N. D. Penny. Both these localities are low on the outer slopes of the northern Coast Ranges (Map 1). Both are in somewhat isolated mountainous regions separated from the higher Cascade Range by the Willamette Valley in Oregon and by Puget Sound in Washington. The species may occur northward into British Columbia and almost surely southward in Oregon. One male was recently collected on snow at 5200-5500 ft, in the Sentinel Hills, Mt. Jefferson Wilderness, Linn Co., Oregon, on 22 March 1981, by Dr. L. K. Russell.

Seasonal Distribution.—The holotype of *macnabeana* was collected in early February, which is about mid-season for the appearance of western Chioneas generally. However, the specimen was taken at a lower elevation than most, which probably relates to its seasonal occurrence, the arrival of winter weather being later there.

Habitats.—The type locality is the "Tillamook burn," a forested area which was swept by fire in 1933, 1939, and again in 1945, only a few months before the specimen of *Chionea macnabeana* was collected. The fly was found on snow about 20 in deep, during a snow storm. The female from the Olympic Peninsula was also found on snow.

Chionea nivicola Doane

Chionea nivicola Doane, 1900: 188-189; Alexander, 1949: 319; Alexander, 1965: 72.

Diagnosis.—A western species with brown coloration, antennae of eight or nine segments (6 or 7 flagellomeres); male gonapophyses blade-like, approximately vertically oriented, female cerci slender, slightly upturned in apical half.

Description.—General appearance: Head dark brown, thorax light brown dorsally, brown at sides; abdominal sclerites light brown to brown, except ninth segment of male darker brown, cerci of female amber colored; pleural membranes pale grayish brown. Length of male about

5 mm, female about 4-8 mm, exclusive of antennae.

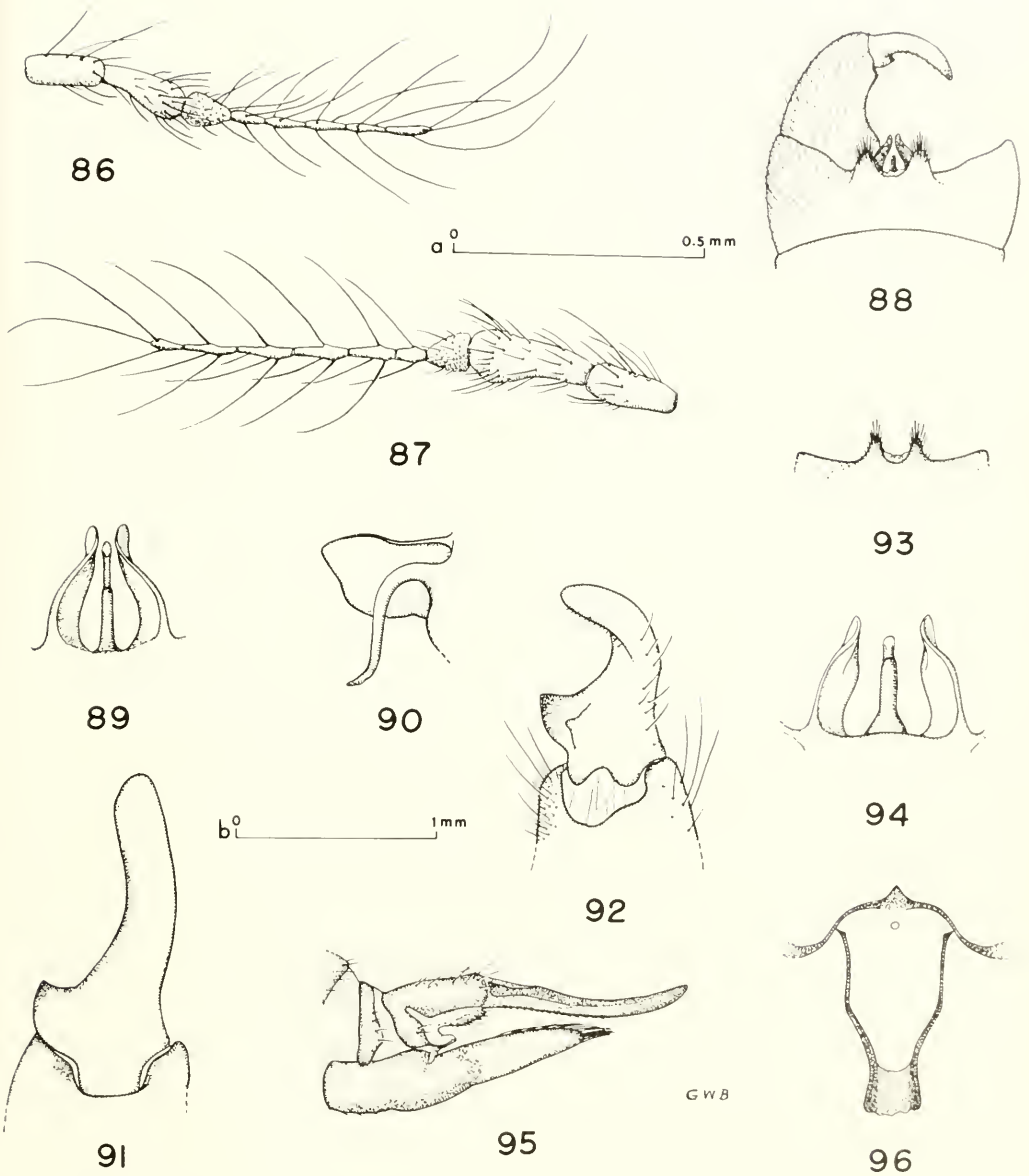
Head: Antennae (Figs. 86, 87) comprising scape, pedicel and six or seven flagellomeres; fusion segment asymmetrically short-conical, about as long as greatest diameter, with apical portion sometimes resembling additional segment. Setae on vertex short, curved, stout. Eyes with about 80-100 ommatidia each.

Thorax: Color of thoracic dorsum light brown to dark yellowish brown centrally, darkening to brown laterally on pronotum and on posterior metanotum; pale grayish brown spot on dorsal mid-line of metanotum in some individuals. Halteres pale grayish brown, contrasting somewhat with color of thoracic dorsum. Mesonotal setae sparse, short, stout, often in transverse patch interrupted at mid-line. Legs long, hind femora extending far beyond end of abdomen, femora light brown, with seven (4 dorsal, 3 ventral) longitudinal rows of short, curved thick and darkened setae; tibial setae longer, more slender. Tarsomeres beyond basitarsi darkening to brown, dark brown on last two.

Abdomen of male: Setae on terga very short, sparse, occurring mostly along posterior and lateral margins. Sternal setae mostly short, on posterior margins, longer and more dense on posterolateral corners of fifth through seventh sterna and on posterior edge of eighth sternum. Posterodorsal margin of ninth tergum (Fig. 88) bearing two prominent, setiferous lobes; median space between these projections broadly U-shaped; 6-11 straight, thick setae on each lobe. Gonapophyses seen from above (Fig. 89) blade-like, almost vertically oriented, curved outward laterally, concave on mesal surfaces with bluntly rounded tips almost touching dorsally, curving apart ventrally; space between gonapophyses broadest basally, usually narrow posteriorly; apex of penis flattened and slightly expanded. Basistyles elongate, slender for genus, sometimes paler than ninth sternum; posteromesal lobes inconspicuous, pilose, evenly rounded. Dististyles (Figs. 91, 92) dark yellowish brown, broad at base, bowed slightly laterad, then more or less evenly curved to acutely rounded apex; mesal tooth near base prominent, subacute; ventral tooth absent in all specimens seen, but small dorsomesal tooth in a few individuals (Fig. 92, cf. *C. scita*). Tenth segment broad at base, evenly narrowed, pigmented and lightly sclerotized laterally.

Abdomen of female: Tergal and sternal setae more numerous and more evenly distributed over sclerites than in males. Eighth tergum at sides about half as long as seventh, shorter dorsally, with three to five posterolateral setae. Hypovalves of eighth sternum slender, elongate, with upper margin gradually and evenly curved downward, lower margin straight for most of its length, then curved upward to tip (Fig. 95). Arms of genital furca tapering rather evenly from base to tip, more strongly divergent in basal half than in apical half, with noticeable bend near mid-length (Fig. 96); basal portion wider than long, not densely sclerotized medially; entire structure lyriform. Mid-ventral portion of ninth sternum (Fig. 96) lightly sclerotized, produced caudad as short, acute or subacute point. Cerci elongate, slender, about eight to nine times as long as greatest width, slightly curved upward in apical half, in some specimens widened beyond mid-length, noticeably longer than hypovalves (about 1.3-1.4 times as long as hypovalve measured from notch to tip; Fig. 95).

Types.—Four female syntypes, Pullman (Whitman Co.), Washington, published without further data. I have seen three of these, which are now in the United States National Museum, Washington, D.C. Two (pinned) are labelled Pullman, Washington, on snow, R. W. Doane collector, and dated 9 January and 12 January 1899; both have been given U.S.N.M. catalogue number 7025. The third I have



Figs. 86-96, *Chionea nivicola*. 86, right antenna of pinned female, lateral aspect. 87, right antenna, female from Oregon, in fluid, mesal aspect, showing six flagellomeres beyond fusion segment. 88, ninth abdominal segment of male from Washington, dorsal aspect (left basistyle and dististyle omitted). 89, typical gonapophyses and penis, dorsal aspect. 90, left gonapophysis and penis, right lateral aspect; cf. Fig. 94. 91, right dististyle, ventral aspect. 92, left dististyle, dorsomesal aspect. 93, posterior margin of ninth tergum, small male from Idaho, dorsal aspect. 94, atypically widely separated gonapophyses, dorsal aspect (same male as Fig. 90). 95, terminal abdominal segments, female syntype (USNM), left lateral aspect. 96, ninth sternum and genital furca, female, ventral aspect. Scales: a—86-87, 89-92, 94, 96; b—88, 93, 95.

cleared and mounted on a microscope slide. It was labelled "*Chionea*—on snow, 12-5-99." The remaining syntype is in the collection of Washington State Univ., Pullman.

Variation.—Among the specimens examined, about half have five flagellomeres beyond the fusion segment, the others six, with the first being shortest (Fig. 87). Some individuals have a dark brown median longitudinal stripe on the vertex and occiput. One female was seen in which the halteres contrasted conspicuously with the thoracic dorsum by reason of its unusually dark color. The cerci of some females are slightly but noticeably widened in the apical half, which increases the curvature of the ventral margin and gives the cerci the appearance of being more abruptly upturned. In a few of the larger, more robust males, the basistyles are thicker than illustrated, but the ventral tooth of the dististyle is not developed as it is in robust males of some other species in which it is more often absent. Although the tips of the gonapophyses are usually strongly convergent (Figs. 88, 89) and rarely are seen in contact, they may be widely separated (Fig. 94). The penis is ordinarily more upcurved apically than as shown in Figure 90. Occasional presence of a small tooth on the inner surface of the dististyle and more dorsal than the large mesal tooth (Fig. 92) has been mentioned in the description.

Size variation, as usual for the genus, is striking. In a population from Latah Co., Idaho (Moscow Mountain), sampled on 9 December 1971, the shortest male was only .67 times as long as the largest male, and its hind femur was only .53 times as long as that of the largest male. Although the basistyles of the smaller males were considerably more slender in lateral aspect than those of more robust males, their length—probably of more functional importance in grasping the female—was in a ratio of about .82 to 1. Other genitalial measurements also showed less size variation: width of ninth tergum .76 to 1, length of dististyle 1 to 1, length of gonapophyses approximately 1 to 1.

Certain parts of the original description, notably the references to concave areas on the femora and tibiae and to the abdomen's being only six-segmented, are somewhat misleading and are based upon Doane's observation of dried, rather shriveled specimens.

Relationships.—While antennal structure, the eighth abdominal tergum of the female and perhaps body color suggest *C. nivicola* belongs with the *valga* group, the form of the male gonapophyses does not support this placement. The gonapophyses are in fact most like those of *C. albertensis*. The long, slender cerci and hypovalves of the female also resemble those of females in the *scita* group. Presence of a prominent mesal tooth and occasional dorsomesal tooth at the base of the dististyle is similar to the condition seen in *C. scita*. The long and, even in males, not greatly thickened femora in *nivicola* resemble those of *albertensis*. Within the *scita* group *nivicola* is easily recognized by its body color and number of antennomeres. In the field it may occur together with *albertensis* but also frequently with *alexandriana* and *obtusa*, which it resembles in general coloration. From these it may readily be differentiated by having longer antennae than *alexandriana* (6 or 7 flagellomeres in *nivicola*, only 3 or 4 in *alexandriana*) and tergal lobes (♂), slender cerci (♀) and short femoral setae, contrasted with absence of tergal lobes, short, thick cerci and conspicuously long femoral setae in *obtusa*. The short, thick setae of head, thoracic dorsum, abdomen and legs are found elsewhere among North American species only in *C. stoneana*.

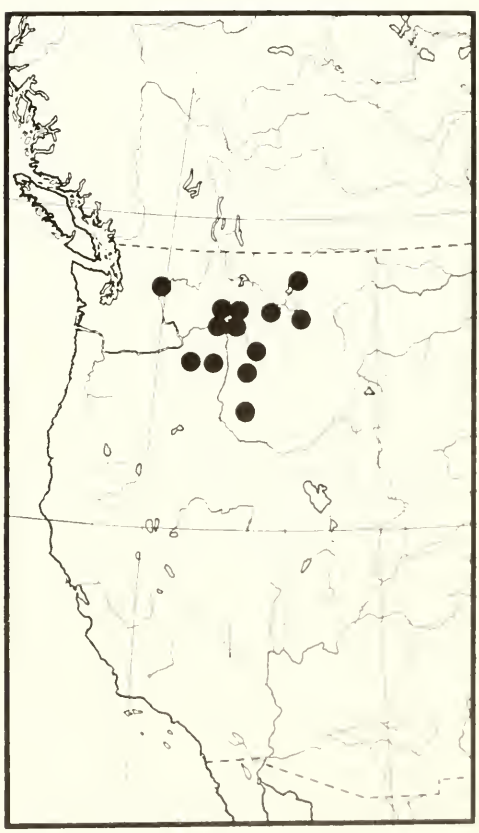
Geographic Distribution.—As now known, the range of *C. nivicola* includes the Columbia Basin and the mountains surrounding it: the eastern Cascade Range

to the west, the Blue Mountains to the south, and the Salmon Mountains, Clearwater Mountains and Bitterroot Range to the east and northeast, but also over the last of these to the western slopes of the Rocky Mountains in Montana (Map 2). I expect the species may range into southwestern Canada and perhaps may occur in the eastern Cascade Range of Oregon.

Seasonal Distribution.—Records for mid-November are from mountainous areas at higher elevations than the Washington and Idaho localities at which *C. nivicola* was taken in December and January. This seems to conform to the general pattern of earlier appearance of *Chionea* in areas where cold winter sets in first and subsequent appearance at lower latitudes or elevations. This pattern of seasonal distribution suggests a second generation of *nivicola* may occur in March and April in the colder parts of the range.

Habitats.—Most specimens were found on snow, in areas of fairly open forest, at elevations from about 740 to 1850 m, or 2400 ft (type locality) to 6000 ft or more (Oregon). The Oregon specimens taken beneath a log may well have been in an excavation made by a small mammal. There have been too few observations or collections made to justify any other generalizations about the habitats.

Collection Records.—IDAHO: Benewah Co., Crystal Creek, on snow, 22 Dec. 1968, M. Furniss (1 ♂, 2 ♀); Boise Co., Idaho City, 14 Dec. 1974, G. A. Shook (1 ♀); Clearwater Co., 8 mi N of Elk River, 14 Nov. 1961, E. H. Dustman (1 ♂); Idaho Co., Clearwater National Forest, Mud Creek Jct., 25 Nov. 1978, R. C. Biggam and M. A. Maurer (1 ♂, 1 ♀); Mud Creek, Lolo Creek Canyon, 14 Nov. 1975, R. C. Biggam (1 ♂); Latah Co., Moscow Mountain, 9 Dec. 1971, G. W. Urich (10 ♂, 6 ♀); 3 mi S of Helmer, Little Boulder Camp, 4 Dec. 1971, W. J. Turner (1 ♂, 2 ♀); 8 mi E of Moscow, Robinson Lake Road, 6 Dec. 1972, Dunn and Michta (3 ♂, 3 ♀); Big Meadows Rec. Area, 4.5 mi NNW of Troy, 9 Dec. 1973, M. C. Hunter (2 ♀); Moscow, on snow, 8 Dec. 1961, R. E. Steeker (5 ♂, 4 ♀); Latah Co., on snow, 14 Dec. 1960, W. F. Barr (2 ♂, 7 ♀). MONTANA: Flathead Co., Big Fork, 12 Nov. 1973, R. A. Haick (2 ♀); Mineral Co., St. Regis, on snow, 28 Dec. 1957, H. R. Dodge (1 ♂); Missoula Co., Missoula, on fresh snow, about 32°F, 16 Nov. 1952, J. A. Chapman (1 ♀). OREGON: Umatilla Co. (southeast), Bowman Meadows to Fly Creek, on snow, 16 Nov. 1962, J. Schuh and E. Hansen (1 ♂, 3 ♀); Fly Creek valley, under log, 15 Nov. 1961, J. Schuh (1 ♂, 1 ♀); Wallowa Co., Wallowa-Whitman National Forest, Eagle Cap Wilderness, 6000-7000 ft, weather clear, 24 Nov. 1972, A. Greene (1 ♀). WASHING-



Map 2. Range of *Chionea nivicola*. Each spot represents one or more collections within a county.

TON: Chelan Co., Stevens Pass, near 4100 ft, 17 Feb. 1973 (1 ♀); Garfield Co., Saddle Butte, Blue Mountains, 9 Nov. 1970, J. Eves and R. D. Akre (3 ♂, 2 ♀); Whitman Co., Pullman, 5 Dec. 1899 (1 ♀), 9 Jan. 1899 (1 ♀), 12 Jan. 1899 (1 ♀), all collected by R. W. Doane (types); Pullman, 15 and 16 Dec. 1970, W. J. Turner (1 ♂, 2 ♀); 7 mi NW of Colton, 21 Nov. 1973, L. Richards (1 ♂).

Chionea scita WALKER

Chionea scita Walker, 1848: 82-83; Byers, 1963: 160; Alexander, 1965: 72.

Chionea primitiva Alexander, 1917: 204-205, Figs. 1, 4; Alexander, 1919: 805, 903; Leonard, 1928: 694; Alexander 1942: 428-429.

Diagnosis.—A northeastern species having yellowish brown color, antennae of 12 (rarely 11 or 13) segments, male gonapophyses blade-like, vertically oriented, ninth abdominal tergum entire, without projecting lobes; female cerci evenly curved, not greatly elongated; hypovalves long with nearly straight ventral margins.

Description.—General appearance: Head dark yellowish brown to light brown, thorax yellowish brown; abdominal sclerites yellowish brown faintly mottled with brown; ninth segment of male dark yellowish brown, cerci of female light amber colored; pleural membranes dull, sordid yellowish brown. Length of male about 5-8 mm, female about 6-8 mm, exclusive of antennae.

Head: Antennae (Fig. 97) comprising scape, pedicel and usually ten flagellomeres, rarely only nine or as many as 11; fusion segment elongate, conical, longer than its basal diameter, covered with short, fine hairs; second flagellomere also covered with short hairs, third and succeeding segments verticillate, with three, sometimes four, setae. Eyes with about 180-200 ommatidia each.

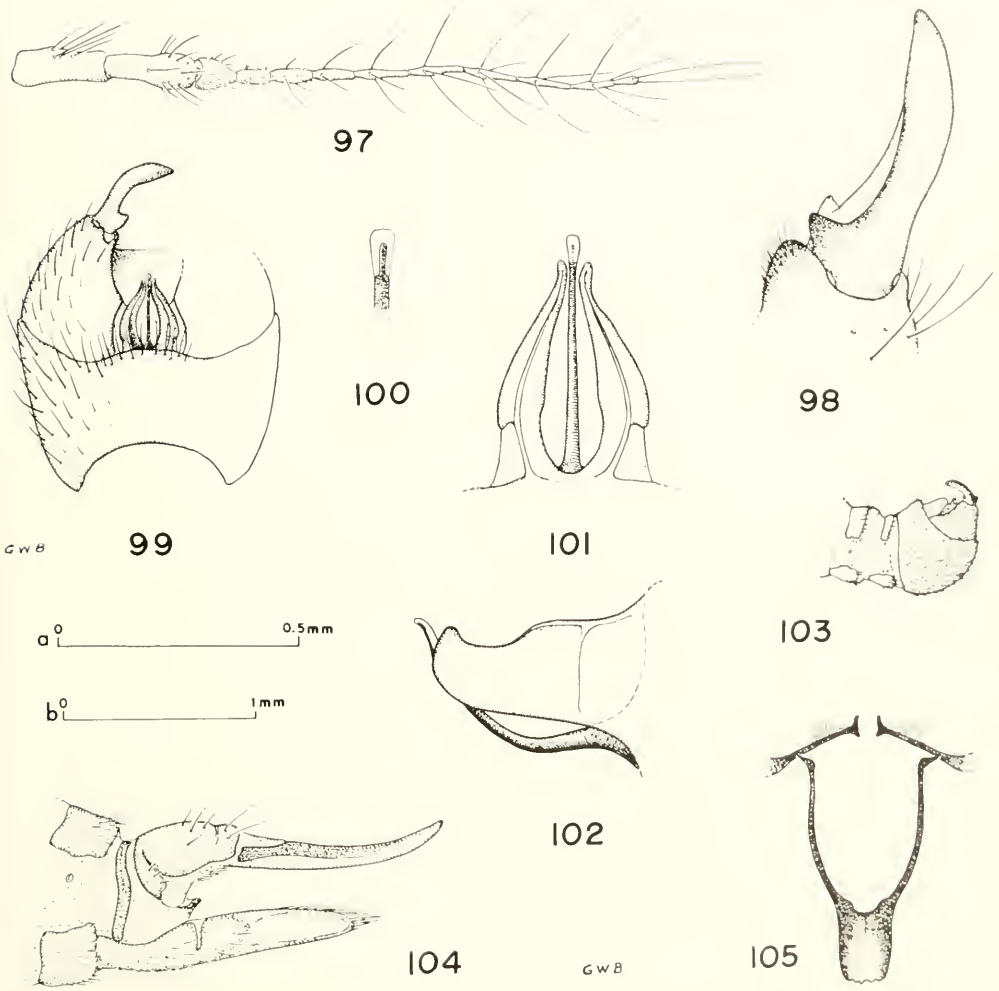
Thorax: Halteres dull, pale yellowish brown, not contrasting sharply with color of thoracic dorsum. Femora, tibiae and proximal three-fourths of basitarsi yellowish brown, tarsi otherwise dark brown. Femoral setae arranged in four dorsal, three ventral rows, smaller hairs sometimes not aligned with setae. Mesonotal setae long, erect, conspicuous.

Abdomen of male: Posterodorsal margin of ninth tergum (Fig. 99) entire, without projecting lobes, broadly and evenly rounded, arched upward and projecting slightly caudad (appearing broadly emarginate when seen in posterodorsal aspect), bearing about a dozen marginal setae sometimes in two weakly defined groups. Gonapophyses (Figs. 101, 102) slenderly triangular in dorsal profile, with thickened dorsal margins, apices turned slightly inward; form in lateral aspect blade-like (Fig. 92), lower margin curving smoothly upward to meet irregular dorsal margin at upturned, narrowly rounded apex; space between gonapophyses narrow, rounded basally, slightly constricted near base; penis evenly curved, its membranous apex spatulate, with slender ventral sclerotized reinforcement (Fig. 100). Basistyles thick, their posteromesal lobes pilose, simply rounded. Dististyles (Fig. 98) evenly curved beyond base, yellowish brown, with strongly sclerotized, blackened mesal tooth, from which a darkened ridge extends along inner, lower surface of dististyle toward tip, in most specimens; dorsomesal tooth low, blunt, rarely rudimentary or absent. Tenth segment as broad basally as space between basistyles, narrowed evenly toward apex, lightly sclerotized and pubescent on lower, outer surfaces (pushed into ninth segment and not shown in Fig. 99).

Abdomen of female: Eighth tergum short (i.e., slender) throughout (Fig. 104), most densely sclerotized along anterior margin, with narrow, yellowish posterolateral edges. Hypovalves of eighth sternum elongate, slender, tapered toward narrowly rounded apex, lower margins

more or less straight, upper margins curving slightly downward. Arms of genital furca divergent from basal plate, then subparallel for about half their length until apically curved outward to join ninth sternum (Fig. 105); basal plate not densely sclerotized medially except for narrow, transverse bar connecting arms. Ninth sternum formed by two converging, slender, well sclerotized bands which arch upward and backward, ending in small longitudinal bars, parallel and separated by a narrow, clear zone at mid-line (Fig. 105); a lightly sclerotized area with rounded margin above terminal portion of each band of sternum. Cerci elongate, about seven to eight times as long as greatest width, noticeably longer than hypovalves (about 1.20-1.36 times as long as hypovalves measured from notch to tip).

Types.—Holotype, female, labelled "North America" but without further



Figs. 97-105, *Chionea scita*. 97, left antenna, male holotype of *C. primitiva*, mesal aspect; length 1.55 mm. 98, right dististyle, ventromesal aspect. 99, ninth abdominal segment of male from Michigan, dorsal aspect (left basistyle and dististyle omitted). 100, apex of penis, dorsal aspect. 101, gonapophyses and penis, dorsal aspect. 102, same, right lateral aspect. 103, terminal abdominal segments, male, left lateral aspect. 104, terminal abdominal segments, female, left lateral aspect. 105, ninth sternum and genital furca, female, ventral aspect. Scales: a—97-98, 101-102, 105; b—99, 104.

data. The type was originally in the British Museum (Natural History) but has been lost sometime since 1953. In that year I sent sketches of diagnostic features of females of *Chionea valga* and what I then called *C. primitiva* to Dr. Paul Freeman, Curator of Diptera in the British Museum. He compared my sketches with the type and confirmed that *primitiva* is the same as *scita*. Subsequently, however, the holotype of *scita* became misplaced, and neither Dr. Freeman nor I was able to locate it when we searched briefly in 1955 and again more thoroughly in 1960. The holotype of *C. primitiva* Alexander is a male from Cascade, Owasco Lake, Cayuga Co., New York, collected on 15 November 1915 by Bishop and Crosby. It is mounted on a microscope slide in the collection of Dr. C. P. Alexander, Amherst, Massachusetts (transferred in 1981 to the U.S. National Museum, Washington, D.C.).

Variation.—Among the many specimens examined, only two had eight flagellomeres beyond the fusion segment, and only one had ten; thus, it can be said that the total number of antennal segments is ordinarily 12. Walker described *scita* as having antennae with black flagella. Since, at the time Dr. Freeman compared the holotype with my drawings, both its flagella were missing, I cannot explain this except to surmise that Walker had viewed the specimen against a pale or illuminated background. The description of the ninth abdominal tergum of the male, above, pertains to the dorsal aspect; because the tergum is somewhat arched upward, it may appear broadly emarginate in posterodorsal aspect. The ventral tooth at the base of the dististyle, which is absent or minute and not darkly colored in some species and even in some males of *scita*, is usually both enlarged and darkly sclerotized. The "tuft of stout black hairs" referred to in the original description of *C. primitiva* (Alexander, 1917: 205) is a group of short, inconspicuous hairs on the mesal face of the dististyle, near the base, occurring in this and all other species. Alexander also described the legs as having all the femora enlarged, which is true of males but not females. Variation in the female cerci and hypovalves has been noted above. In most females the pleura of the tenth abdominal segment hang down at each side in a fleshy, semicircular fold, partially concealing the ninth sternum in lateral view. These folds are more prominent in *scita* than in most other species (Fig. 104).

The specific name is derived from Latin *scita*, meaning beautiful or handsome.

Relationships.—This species is one of four in North America that have yellowish brown overall coloration, antennae with more than nine segments, the eighth abdominal tergum of the female short, and the male gonapophyses blade-like and more or less vertically oriented. These species, together with *nivicola*, comprise the *scita* group. Within this group, *Chionea scita* is set somewhat apart from the other three yellowish species, *C. albertensis*, *C. macnabeana* and *C. wilsoni*, on the basis of such characters of the female as the ninth sternum, the furca and the setae on the abdominal sclerites. Both *scita* and *macnabeana* have 12 antennal segments, as compared to 11 in *albertensis*, but in view of the known individual variation in this character and the fact that *macnabeana* is based upon so few specimens, I would place more reliance in the genitalial characters as indicators of relationship. Males of *scita* differ from those of *albertensis* in having the ninth abdominal tergum entire instead of bilobed, the penis spatulate at the tip instead of forked, the surface of the gonapophyses less undulating than in *albertensis* and the tips less acute. In *scita* there is usually a darkened ridge extending distad from the darkened mesal tooth of the dististyle, while in *albertensis* this tooth is ordinarily not conspicuously blackened, and if a ridge

extends distad from it, the ridge is not blackened. Moreover, *scita* lacks the darkly sclerotized ventral tooth seen in *albertensis*. Some other, less outstanding differences will be found in the discussion of the relationships of *C. albertensis*.

Geographic Distribution.—As now known, the range of *Chionea scita* extends from Massachusetts and northern Vermont westward across New York to southeastern Michigan, southwestward to eastern Kentucky, and southward along the Appalachian Mountains to northern Georgia, presenting a rather distinct and coherent pattern, except for the Georgia record (Map 1). Very likely the species ranges further northward, throughout New England and well into southern Ontario and Quebec and the Maritime Provinces. It will certainly be found more widely along the lower slopes of the Appalachian Mountains.

Seasonal Distribution.—Dates of collection of *scita* extend from the middle of September to the middle of February, but the one September record is from the northernmost locality from which the species is known (northern Vermont). The one October record and the single one from January are both from cave environments, while the February collection is from a southern but montane environment. All other records are in November and December, and even at the West Virginia locality most specimens were collected in December. From this evidence I am inclined to believe that there is only one generation per year.

Habitats.—This is the only species in which most of the specimens seen were taken from places other than the surface of snow. The most outstanding collection of *Chionea scita* is that made by Dr. M. S. Briscoe of Howard Univ., Washington, D.C. He set a number of traps in the floor of a cave near Harpers Ferry, West Virginia. These were baited with decomposing meat and were designed primarily to attract cavernicolous Coleoptera; however, he took 29 specimens of *Chionea scita* in addition to the other insects. This collection has been discussed earlier under the natural history of *Chionea*. Mr. Roger Sperka of the Univ. of Kentucky similarly found one female specimen in a cave in Kentucky. It would seem, therefore, that the occurrence of *scita* in fair numbers and well back from the cave entrance was no chance phenomenon and that having wandered into caves, these Chioneas might become at least semipermanent cave insects. Where I collected *scita* in southeastern Michigan, the habitat was a sparsely wooded shore of a marsh and the microhabitat a series of cavities in the loose soil and finely divided, decayed wood beneath a stump in the advanced stages of decay. The debris included, besides soil and wood particles, various other bits of plant matter, fragments of dead insects, etc., and although I found no sure evidence that the microhabitat was or had been a rodent nest, I would not rule out this possibility. The holotype of *C. primitiva* also was not found on snow but in leaf mold. The occurrence of *scita* at light in Pennsylvania is particularly interesting and has been discussed elsewhere under behavior of the adult flies.

Collection Records.—GEORGIA: Union Co., Vogel State Park, in pit-fall trap, elevation about 3200 ft, 10 Feb. 1972, J. Howell (1♀). KENTUCKY: Pulaski Co., Wind Cave (37°03′N, 84°31′W), elevation 840 ft, 24 Oct. 1970, R. Sperka (1♀). MASSACHUSETTS: Hampshire Co., Amherst, 13 Nov. 1933 (1♀); same, 14 Nov. 1933 (1♂); both collected by A. B. Gurney. MICHIGAN: Oakland Co., Highland Recreation Area, 4 mi E of Highland, 8 Nov. 1952, P. B. Kannowski (1♂); same locality, 12 Nov. 1952, G. W. Byers, D. Hynes, P. B. Kannowski (2♂, 2♀). NEW YORK: Cayuga Co., Owasco Lake, Cascade, in leaf mold, 15 Nov. 1915, Bishop and Crosby (1♂, holotype of

C. primitiva Alexander); Schuyler Co., Van Etten, Arnot Forest, Nov. 1927, R. D. Harwood (1 ♂); Steuben Co., Lake Keuka, Dec. 1905, Crosby collection (1 ♂); Sullivan Co., Surprise Cave, 11 Nov. 1966, S. Peck (1 ♀); Tompkins Co., Ithaca, 18 Nov. 1892, R. H. Petit (1 ♂); Ithaca, Needham's Glen, 12 Dec. 1932, J. G. Needham (1 ♂); Ithaca, 15 Dec. 1907 (1 ♂). ONTARIO: Waterloo, on melting snow, 19 Dec. 1977, L. Lesage (1 ♂). PENNSYLVANIA: Erie Co., Edinboro, tributary of Conneauttee Creek, 1465 ft, on outside of emergence trap, 8°C, 16 Nov. 1980, Becky Travis; Centre Co., State College (University Park), on window screen, 11 P.M., possibly attracted to light, 9 Nov. 1961, C. W. Rutschky (1 ♀). VERMONT: Chittenden Co., 6 mi N of Bolton (Upper Bryant Lodge), elevation 3000 ft, on snow, 14 Sept. 1954, Rodger Mitchell (1 ♀). VIRGINIA: Smythe Co., Lewis Fork at Rte. 603, 19 Jan. 1981, B. Kondratieff (1 ♂). WEST VIRGINIA: Jefferson Co., near Harpers Ferry, in cave, 8-15 Dec. 1939 (2 ♂); same, but 15 Dec. 1939 (13 ♂, 13 ♀); same, but 6 Jan. 1948 (1 ♂, 1 ♀); all collected by M. S. Briscoe.

Chionea wilsoni, NEW SPECIES

See Appendix 1.

THE C. valga GROUP

Body color in general reddish brown, grayish brown or dark brown; antennae with one to six flagellomeres beyond fusion segment; gonopophyses of male in form of upper horizontal blade (usually more or less impressed or bent downward in middle) with vertical keel and without slender apical hook; eighth abdominal tergum of female approximately half length of seventh tergum (or expanded at sides in *hybrida* and *stoneana*). Included species: *hybrida,* new species, *obtusa,* new species, *stoneana* Alexander and *valga* Harris.

Chionea hybrida, NEW SPECIES

Diagnosis.—A western montane species of dark grayish brown color, with antennae having two or three flagellomeres; male gonapophyses elongate, concave dorsally, convergent apically, keeled ventrally; female cerci slightly longer than hypovalves, eighth tergum widened laterally.

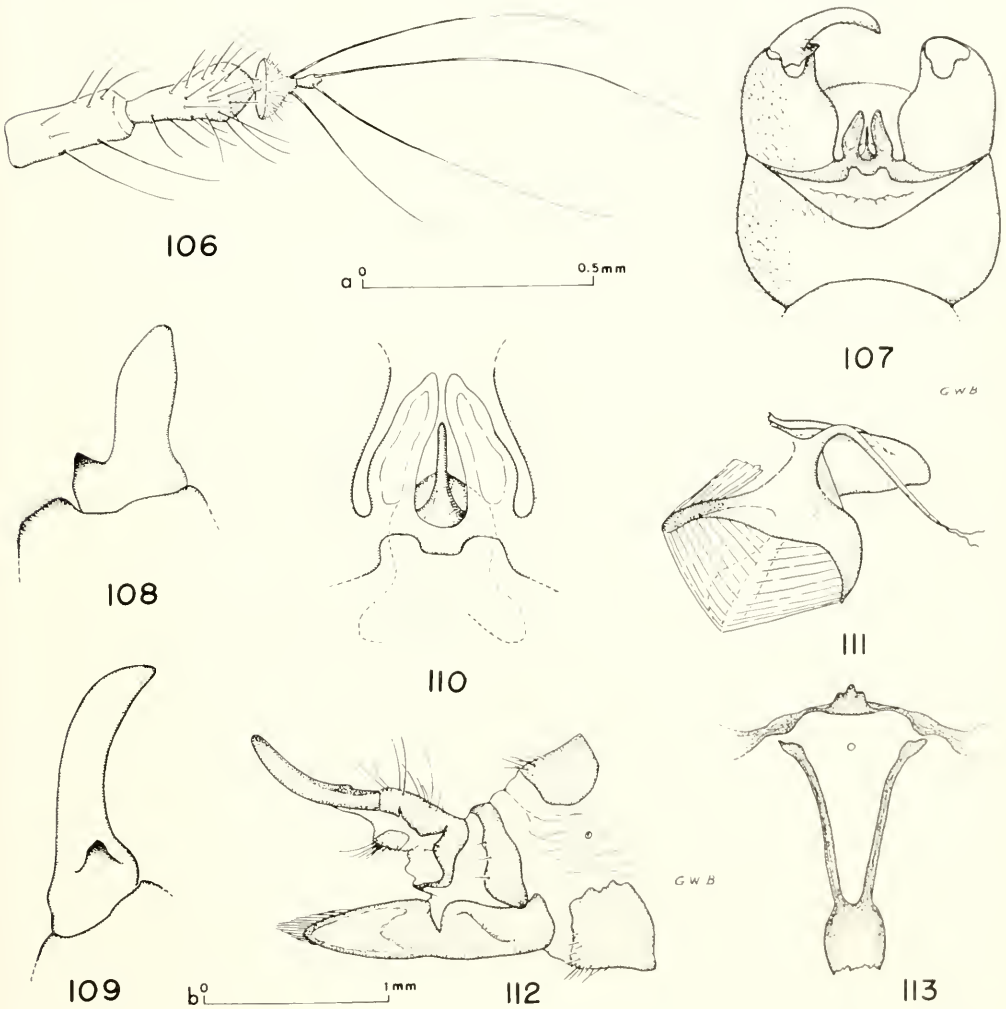
Description (based on 2 ♂, 1 ♀, preserved in alcohol; 6 ♂, 11 ♀, pinned.—General appearance: Head including palps and antennae dark grayish brown, thorax dark brown to dark grayish brown, nearly black in dried specimens; abdominal sclerites brown to nearly black, ninth segment of male darker than other abdominal segments in specimens preserved in alcohol, all segments approximately same color in dried specimens; cerci of female dark amber colored; pleural membranes grayish in alcoholic specimens to dark grayish brown in pinned ones; fine, silvery pollinosity on head, thorax and to lesser extent on abdomen, visible in light from certain angles especially in dried specimens. Length of male about 2.9-4.9 mm; female about 4.4-5.9 mm, exclusive of antennae.

Head: Antennae (Fig. 106) consisting of subcylindrical scape, distally enlarged pedicel, short, broadly conical fusion segment, and usually one additional flagellomere bearing only two terminal setae. Eyes with about 110 facets in male, 100 in female.

Thorax: Halteres paler than dark grayish brown color of thoracic dorsum, pale grayish brown in alcoholic specimens, darker when dried. Legs brown to dark reddish brown, hairs long and thin (as is *C. valga*), not in distinct rows; in large males, hairs on femora, tibiae and basitarsi bent or slightly curled at apex, this less common in slender males and females; hairs of tibiae and basitarsi 1.3-1.5 times as long as diameter of segment. Tarsi generally same color as legs, but due to fine pubescence fifth tarsomere may ap-

pear darker than others in most lights.

Abdomen of male: Terga 1-8 sparsely hairy, corrresponding sterna slightly more hairy. Posterodorsal margin of ninth tergum (Fig. 107) broadly and smoothly emarginate, without lobes or prominences. Gonapophyses (Figs. 110, 111) elongate, convergent apically, each gradually tapering to narrowly rounded tip, with shallow, trough-like dorsal concavity and strong ventral keel; space between gonapophyses shaped like narrow-necked flask; penis arched upward at base, then curved downward, with two sinuate apical filaments. Basistyles thick, with inconspicuous, pilose posteromesal lobe. Dististyles (Figs. 108, 109) reddish brown, generally smooth-surfaced, glossy on outer curvature, much



Figs. 106-113, *Chionea hybrida*. 106, right antenna, male holotype, dorsolateral aspect. 107, ninth abdominal segment, male holotype, dorsal aspect (left dististyle and hairs of left side omitted, tenth segment pushed inward). 108, right dististyle, holotype, ventrolateral aspect (apex concealed by curvature). 109, left dististyle, ventral aspect. 110, gonapophyses and penis, holotype, dorsal aspect (outline of apodemes of vesica indicated by dashed line). 111, right gonapophysis, penis, vesica and its apodemes and muscles, left lateral aspect (cut muscle connects to base of left gonapophysis). 112, terminal abdominal segments, female allotype, right lateral aspect. 113, ninth sternum and genital furca, allotype, ventral aspect. Scales: a—106, 108-111, 113; b—107, 112.

thickened at base with acutely pointed, darkly sclerotized mesal tooth, otherwise of generally uniform width throughout until near apex.

Abdomen of female: Segments 1-8 dark grayish brown, sparsely hairy. Eighth tergum widened (i.e., lengthened) at sides (Fig. 112). Upper and lower margins of hypovalves approximately equally curved toward apex. Cerci nearly straight in basal half, curved upward just beyond mid-length, with tips rounded, not acute; cerci slightly longer than hypovalves (ratio 1.1:1). Arms of genital furca of approximately uniform thickness throughout, evenly divergent from basal portion; sides of basal portion curved outward slightly (Fig. 113). Median projection of ninth sternum with three teeth, middle one longest and most distinct.

Types.—Holotype, male, and female allotype, Temple Fork, Logan Canyon, Cache Co., Utah, 27 January 1968, W. D. Pearson and R. H. Kramer. Paratypes, 7 ♂, 11 ♀, as follows: UTAH: Cache Co., Logan Canyon, Temple Fork, 10 Feb. 1968, W. D. Pearson and R. H. Kramer (1 ♂, in alc.); Cache Co., Logan Canyon, Beaver Mountain, 20 Jan. 1974 (1 ♀); Cache Co., Logan Canyon, Sink Hollow, A.M., on ski tracks in fresh snow, 20°F, 7 Dec. 1974, T. and F. Whitworth (3 ♂, 6 ♀); Rich Co., in spruce-fir forest, 6 Dec. 1975 and 22 Jan. 1977, respectively, K. Smith (1 ♂, 1 ♀); Wasatch Co., 6 mi from U.S. Hwy. 40 near Strawberry River, 23 Nov. 1975, J. M. Payne (1 ♂, 3 ♀). IDAHO: Franklin Co., Franklin Basin, near Utah border, 14 Jan. 1978 (1 ♂). Holotype and allotype have been cleared but are not slide-mounted; paratypes pinned except as indicated. Holotype, allotype and 3 ♂, 3 ♀ paratypes in Snow Entomological Museum, Univ. of Kansas; remaining paratypes in collection of Utah State Univ., Logan, Utah.

Variation.—There is a third seta on the terminal flagellomere in a few individuals, but it is much shorter and more slender than the other two. About one-third of the specimens seen have two flagellomeres beyond the fusion segment. One male paratype has a small ventral tooth on the outer base of the dististyles. Variation in number, length and distribution of setae on head, thorax and abdominal sclerites is considerable, as typical for the genus. Similarly, both slender-legged males (e.g., one 2.9 mm long) and robust males (4.9 mm long) with much thickened femora exist, even in the small sample now at hand.

Relationships.—Chionea hybrida exhibits an unusual combination of taxonomic characteristics of the *valga* and *alexandriana* species groups; hence the name *hybrida*. The structure of the gonapophyses and absence of projecting lobes on the ninth tergum would place males of the species near *valga*. In the female the form of the eighth abdominal tergum resembles that of *valga,* and the abundant, long and slender setae of the legs give both males and females the general look of *valga* or *obtusa*. But the shape of the female's ninth sternum recalls that of *alexandriana* or *nigra*. Similarly, the very short antennal flagellum resembles that of some species in the *alexandriana* group that occur in the western states, yet in *stoneana* one finds the flagellum equally reduced. Males of *C. hybrida* may readily be differentiated from those of other western species by reference to the ninth tergum, gonapophyses and antennae; females, which somewhat resemble *nivicola* in form of eighth tergum, or *jellisoni* in having short antennae and rather short cerci, may be separated from these species by the fuzzy appearance of the setae on the legs and usually, as well, by the antennal structure.

Geographic Distribution.—At present, *C. hybrida* is known only from the northern Wasatch Range of northern Utah and adjacent Idaho (Map 3). Its actual range probably does not extend very far beyond

this, perhaps a little farther south and north along these mountains and possibly eastward into the Uinta Mountains. The range as now known falls within that of *C. jellisoni* and adjoins the westermost extension of the range of *C. nigra*.

Seasonal Distribution.—There is probably a single annual period of adult emergence prolonged over about three months. The few specimens known were taken in only eight collections fairly evenly spread over the period from late November to early February.

Habitats.—In general, the region in which *C. hybrida* lives is one of western yellow pine (ponderosa pine) and Douglas fir. The habitat in Rich Co., Utah, is described as spruce-fir forest. Elevations at some of the collection sites are: along Temple Fork, about 1830 m or 6000 ft; in Sink Hollow, upper Logan Canyon, 2225 m (7300 ft); approximately 2256 m (7400 ft) along the Strawberry River; and probably above 2450 m on Beaver Mountain (summit 2698 m). Most if not all of the specimens were taken from the surface of snow.

Chionea obtusa, new species

Diagnosis.—A western species, brown to grayish brown in color, with antennae having five to seven flagellomeres; male gonapophyses, seen from above, broad, deeply concave, with rounded tips, ventral keel with a ventral subapical process; female cerci short, broad, with bluntly rounded, upturned tips; setae of legs long, slender, abundant.

Description (based on 2 ♂ and 3 ♀ on slides, 3 ♀ pinned, and 25 ♂ and 21 ♀ in alcohol).—General appearance: Head dark brown, thorax brown to grayish brown; abdominal sclerites light brown to light grayish brown, except ninth segment of male dark brown, cerci of female yellowish; pleural membranes tan. Length of male about 4-7 mm, female about 4.5-8 mm, exclusive of antennae.

Head: Antennae (Figs. 114, 115) consisting of scape, pedicel and five to eight flagellomeres (six in holotype); fusion segment asymmetrically short-conical, about as long as greatest diameter or a little shorter. Hairs of vertex and clypeus soft, slender, not blackened. Eyes with about 80 ommatidia each.

Thorax: Halteres light brown to gray. Legs brown to grayish brown, with approximately six dorsal and five ventral rows of long femoral setae in males, four dorsal and three ventral in females; in males, additional small setae often present, not in clearly defined rows; tarsomeres beyond basitarsi slightly darker than legs. Notal and coxal setae slender, not blackened.

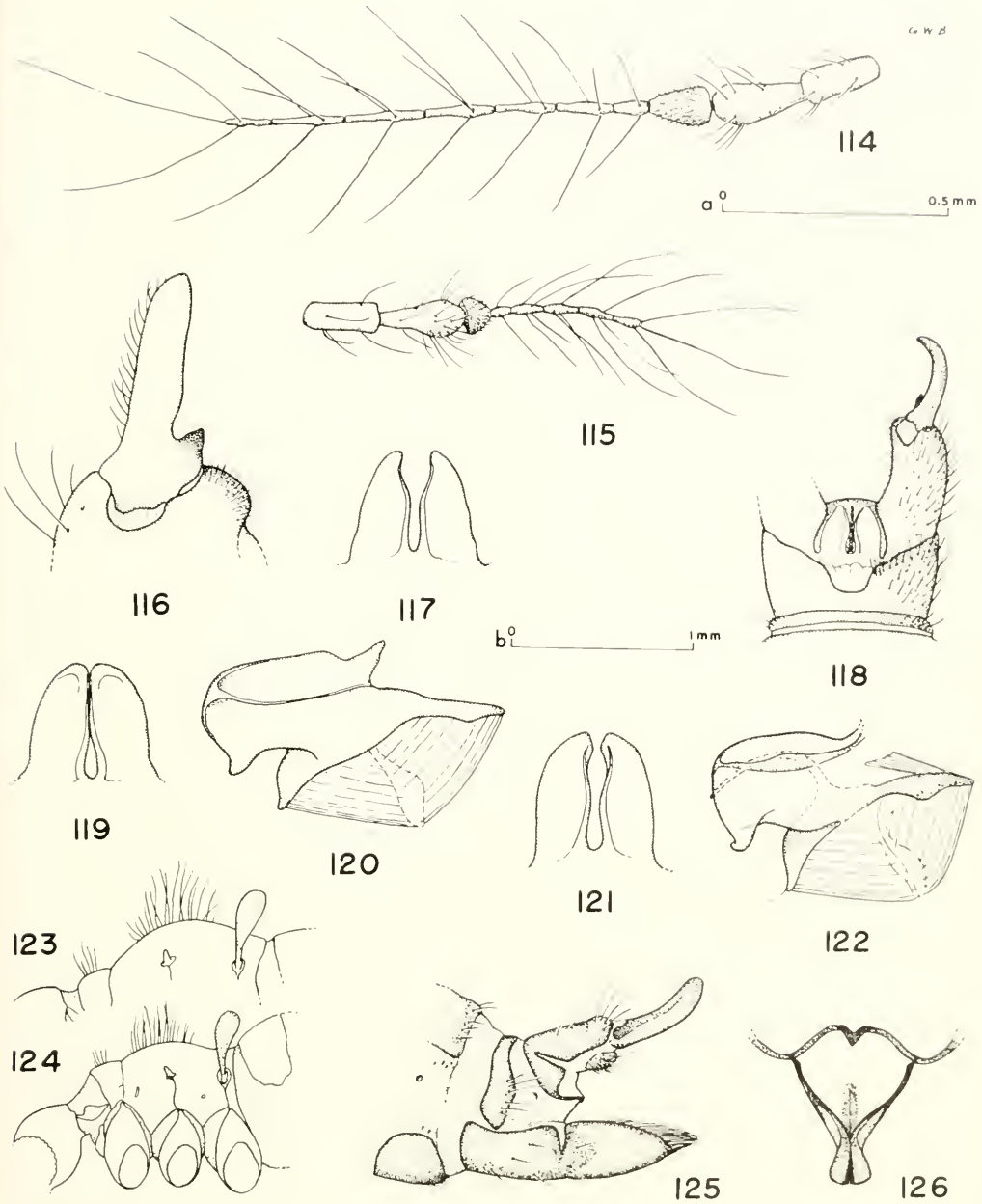
Abdomen of male: Terga 1-6 with long, thin hairs on posterior half, terga 7-8 with hairs in single submarginal row; terga without distinct color pattern. Hairs of sterna chiefly along posterior margins, most dense on posterolateral corners. Ninth tergum (Fig. 118) with broadly U-shaped emargination, a low, wide, scarcely evident lobe at each side of emargination; six to nine setae in approximately transverse row on each lobe, in alignment with more lateral setae of tergum. Gonapophyses (Figs. 117, 119, 121), seen from above, broad, blade-like with upturned lateral margins, thus deeply concave on dorsal surface, with broadly to narrowly rounded tips; deep ventral keel of each gonapophysis with incurved, subapical projection; mesal margins slightly divergent basally, subparallel to slightly divergent in apical half; apex of penis slightly flared, without terminal filaments. Basistyles slender to moderately thick for genus, each with bluntly rounded, pilose posteromesal lobe. Dististyles (Fig. 116) light brown, slender, rather evenly curved, only slightly thickened at base, with single prominent, blackened mesal tooth separated from base by distinct notch. Base of tenth segment about as wide as emargination of ninth tergum,

segment not abruptly narrowed near mid-length, only lightly sclerotized laterally.

Abdomen of female: Tergal and sternal hairs shorter, more widely scattered over sclerites than in male. Eighth tergum about one-third to one-half as long as seventh, widest at sides, with three or four setae along posterolateral margins (Fig. 125). Hypovalves of eighth sternum short, deep, with ventral margin curving upward, dorsal margin only slightly curved downward to subacute apex. Arms of genital furca broad at base, tapering toward mid-length, slender in apical half, widely divergent (Fig. 126); basal portion not strongly sclerotized except medially, constricted near its mid-length; wide, elongate section of lining of bursa copulatrix visible in cleared specimens (shown as stippled zone in Fig. 126). Ninth sternum formed by junction of slender, darkly sclerotized bands at acute, downward-curved point. Tenth tergum with long setae on posterior margin, otherwise mostly bare. Cerci (Fig. 125) short, thick, only about 3-4 times as long as greatest width, widest near base but when seen from side appearing slightly widened beyond mid-length, upturned in apical half to bluntly rounded tips, subequal in length to hypovalves, measured from notch to tip.

Types.—Holotype, male, Cranbrook, British Columbia, elevation about 1000 m, 17 Nov. (year not recorded), C. B. D. Garrett; on microscope slide no. 6152. Allotype, female, same data as holotype; on slide no. 6162. Paratypes, 27 ♂, 26 ♀, as follows: BRITISH COLUMBIA: Cranbrook, 1 Nov. (1 ♂, 1 ♀, on slides), 2 Nov. (1 ♀), 14 Nov. (1 ♀), 3 Dec. (1 ♀), C. B. D. Garrett. ALBERTA: Boulder Pass, 7490 ft, Banff Nat. Park, on 12-in-deep snow, 14 Oct. 1968, K. W. Richards (2 ♀); Lake Louise, Banff Nat. Park, 6500-7000 ft, 4 Oct. 1973, J. A. Downes (4 ♂, 3 ♀). IDAHO: Benewah Co., Heyburn State Park, 20 Dec. 1975, Albert Greene (1 ♂); Idaho Co., Clearwater Nat. Forest, Mud Creek Jct., 25 Nov. 1978, R. C. Biggam and M. A. Maurer (6 ♂, 4 ♀). MONTANA: Gallatin Co., Taylor Fork, 7500 ft, 1 Nov. 1932, R. E. Wall (1 ♀); Missoula Co., Holland Lookout, Seely Lake, 8012 ft, 4 Oct. 1952, J. A. Chapman (1 ♀); Missoula, on snow, temp. about 32°F, 21 Dec. 1952, J. A. Chapman (1 ♀); Missoula Co., Elk Creek, Lubrecht Forest, 4000 ft, 22 Jan. 1972, R. A. Haick (16 ♂, 12 ♀); Ravalli Co., near Sleeping Child Hot Spring, on 1 ft of snow, 16 Jan. 1972, W. L. Jellison (2 ♂, 1 ♀). OREGON: Wallowa Co., Wallowa-Whitman Nat. Forest, Eagle Cap Wilderness, 6000-7000 ft, weather clear, 24 Nov. 1972, Albert Greene (1 ♂). Holotype, allotype and topotypic paratypes are in the Museum of Zoology, Univ. of Michigan, Ann Arbor, Michigan. Paratypes are in the U.S. National Museum of Natural History (including the C. P. Alexander collection), the Snow Entomological Museum, Univ. of Kansas, and the collections of Washington State Univ., Univ. of Idaho, and Univ. of Alberta. I have also seen 1 ♂ from Sheep Creek, Windermere, British Columbia, 10 Oct. 1927, A. A. Dennys, in the collection of Agriculture Canada, Ottawa; and 1 ♂, 20 Nov 1932, from Edmonton, Alberta, collected by E. H. Strickland, in Dr. Alexander's collection. These two specimens, the first pinned, the second on a slide, have not been made paratypes because I was not able to check certain of their structural details; however, I am reasonably confident of their identification. One further male, from Glacier National Park, British Columbia, Nov. 1975, collected by J. G. Woods, could be positively identified but is considered too damaged to be made a paratype.

Variation.—Among the paratypes from Elk Creek, Montana, males range from 4.0-6.8 mm (mean = 5.3) (one individual 3.5 mm long has a distorted, extremely telescoped abdomen and appears in other ways about the same size as the 4.0 mm



FIGS. 114-126, *Chionea obtusa*. 114, left antenna, large male from Idaho, lateral aspect, showing seven flagellomeres beyond fusion segment. 115, right antenna, male holotype, lateral aspect. 116, left dististyle and apex of basistyle, male from Idaho, posterior (ventral) aspect. 117, gonapophyses, male from British Columbia, dorsal aspect. 118, ninth abdominal segment, male from British Columbia, dorsal aspect (most of right side omitted). 119, gonapophyses, male from Idaho Co., Idaho, dorsal aspect. 120, same, right lateral aspect. 121, gonapophyses, male from Boise Co., Idaho, dorsal aspect. 122, same, right lateral aspect. 123, thoracic dorsum, male, left lateral aspect. 124, thorax, female, left lateral aspect; compare with *C. valga*, Figs. 139, 140. 125, terminal abdominal segments, female, left lateral aspect. 126, ninth sternum and genital furca, female, ventral aspect. Scales: a—114-117, 119-122, 126; b—118, 123-125.

male); females range from 4.5-7.7 mm (mean = 5.8). Small males have slender femora, are relatively sparsely hairy on legs and body, and have slender basistyles. Large males are robust, with incrassate femora, very hairy legs and body, and have thickened basistyles, which, however, are plainly longer than wide, not short and thick as sometimes seen in robust males of *C. alexandriana* and some other species. Males of intermediate length are also intermediate in hairiness, enlargement of femora, and robustness of the ninth abdominal segment. Comparison of measurements of various structures in the smallest and largest males yields some interesting ratios: body length, .59 to 1; length of hind femur, .30 to 1; length of genital bulb, .83 to 1.

All females, whether relatively large or small, are slender-legged. Both large females and small ones have about the same size of eggs (which are usually discernible through the abdominal pleural membrane in alcoholic specimens). Ratios of smallest to largest measurements are as follows: body length, .58 to 1; length of hind femur, .59 to 1; length of cercus, .83 to 1; length of hypovalve, measured from notch to tip, .91 to 1.

These ratios for both males and females demonstrate that despite rather conspicuous variation in some aspects of size, all adults retain reproductive structures of roughly uniform size. Dimensions of the ovipositor are probably influenced by those of the eggs. And for a male to be functional in copulation, his genital structures must accommodate to those of the female, no matter how much other measurements may vary. It is not clear why the observed variation in size exists, but there is probably rather strong selection for reproductive apparatus of "normal" proportions.

Variation in shape of the male gonapophyses and of the space between them, as seen from above, may result in part from slight outward twisting of their tips or compression between the basistyles (Figs. 117, 119, 121).

About 65% of the specimens from British Columbia have four flagellomeres beyond the fusion segment, the others five. In the large sample from Elk Creek, Montana, roughly 40% (among both sexes) have four flagellomeres beyond the fusion segment, while 60% have five. Farther to the south and west, six flagellomeres in addition to the fusion segment is the common condition, with seven found in three robust males. There is thus a clinal increase in number of flagellomeres from north to south.

The holotype is a robust male having incrassate femora, especially on the hind legs, and a wider ninth segment and thicker basistyles than most other males. It also has many femoral setae outside the discernible rows. Femoral and tibial setae, especially in robust males, may be curly at the tips as in *C. valga*. Other variation noted has been included in the description.

Relationships.—The close affinity of *Chionea obtusa* with *C. valga* Harris is shown by the similarity of structure of the gonapophyses and dististyles in the male, the eighth tergum and genital furca in the female, and of the antennae and the hairs of head and body in both sexes. Males of the two species can be distinguished by the ninth abdominal tergum, which is distinctly emarginate medially in *obtusa* but so broadly emarginate as to be virtually entire in *valga*. Both males and females of *obtusa* have the mesonotum only slightly downcurved to the pronotum (Figs. 123, 124), while in *valga* the mesonotum is conspicuously humped, that is, abruptly downcurved to the pronotum (Figs. 139, 140). Females of *obtusa* are readily recognized by their short, bluntly tipped cerci, which are unlike those in any other species, and to which the specific name refers. *Chionea obtusa* also bears some resemblance to *C. nivicola* Doane, with which it sometimes occurs. This is based largely on

the similar number of antennomeres. In males of *nivicola* the gonapophyses are essentially compressed, that is, flattened, vertically oriented blades, and the ninth tergum bears prominent lobes. *Chionea obtusa* also has longer, finer and much more abundant hairs and setae on body and legs than are found in *C. nivicola*.

Geographic Distribution.—The known range of *C. obtusa* extends from the plains of central Alberta to the Rocky Mountains of southeastern British Columbia and adjacent Alberta, to western Montana, northern Idaho and northeastern Oregon, some eight degrees of latitude and four of longitude (Map 3). Although apparently restricted to mountainous areas (up to 2300 m) in most of its range, *obtusa* occurs near 675 m in the vicinity of Edmonton.

Seasonal Distribution.—Dates of collection are in every month from October through January, but separate collections are scarcely numerous enough to show any clear pattern of emergence of adults. Some other western species that are found in autumn (October-November) have a second period of emergence in spring (March-April), and further collecting may well show that this is true also of *Chionea obtusa*. The fact that the entire range of *obtusa* is northern, for the genus, may influence seasonal appearance of adults.

Habitats.—For most of the specimens, no ecological field data are available. The range is generally within the zone of Douglas fir, western yellow pine (ponderosa pine), lodgepole pine, larch and western white pine. The records for Edmonton, however, are possibly from tall grass prairie, which occurs in the immediate vicinity of that city. There is, of course, some possibility that Strickland labelled as "Edmonton" some specimens taken in the nearby subarctic forest of spruce and fir. Most specimens were taken on snow, it appears, and most in wooded areas. The elevational variation in habitats has been mentioned above.

Chionea stoneana Alexander

Chionea stoneana Alexander, 1940: 100-102; Alexander, 1965: 72.

as *Chionea valga*: Lugger, 1896: 230-231 (misidentification).

Diagnosis.—A mid-western species with antennae having three (rarely only two) flagellomeres; male gonapophyses elongate, subparallel blades with acute tips; female cerci strongly upturned in apical half, setae of legs short, not in clearly defined rows.

Description.—General appearance: Head dark brown to blackish brown, thorax blackish brown, slightly paler medially; abdominal sclerites grayish brown, terga slightly darkened laterally; ninth segment of male and eighth through tenth segments of female, except hypovalves, dark brown, cerci grayish amber; pleural membranes pale grayish brown. Length of male about 2.3-5.7 mm, female about 2.3-5.9 mm, exclusive of antennae.

Head: Antennae (Figs. 127, 128) consisting of scape, pedicel and three or rarely two flagellomeres; fusion segment subconical, asymmetrical, usually a little longer than greatest diameter. Setae on vertex pale. Eyes with about 100-120 ommatidia each.

Thorax: Halteres pale grayish brown (in alcohol), contrasting conspicuously with color of thoracic dorsum. Legs grayish brown; femoral and tibial setae more numerous than in most other species, short, pale brown, each arising from a low papilla, not serially arranged, or at least not in clearly defined rows; setae at apical ends of femora and tibiae longer than others; basitarsi of male darkened apically, succeeding segments grading from dark brown to blackish brown on terminal segment; tarsi of female only slightly darker than legs. Setae of pronotum and mesonotum elongate, not blackened.

Abdomen of male: Posterodorsal margin of ninth tergum (Fig. 129) bearing

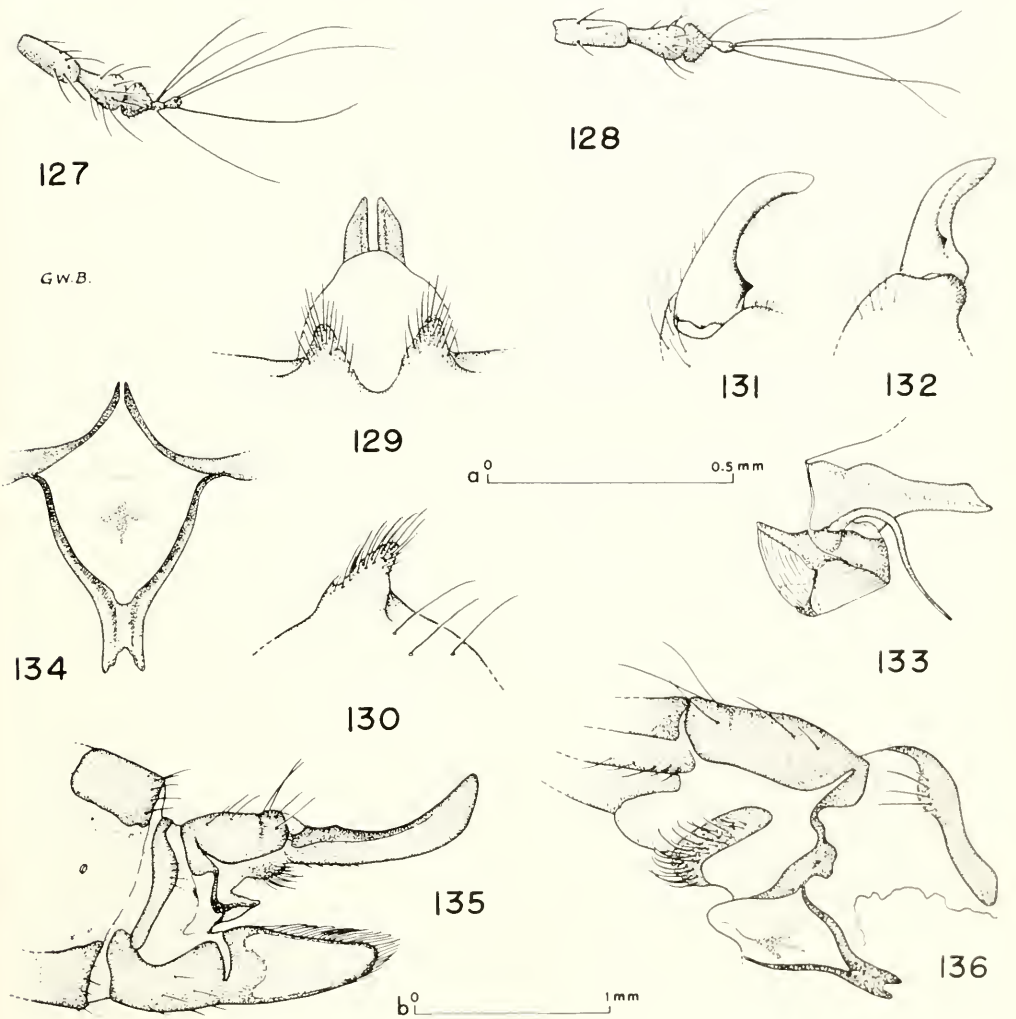
two prominent, blackened, setiferous lobes, with V-shaped to U-shaped space between them; lobes projecting noticeably dorsad (Fig. 130), each bearing about 12 (8-14) brownish setae. Gonapophyses, seen from above (Fig. 129), elongate, parallel-sided, protruding from genital chamber, concave on dorsal surface, keeled ventrally, with sharply pointed apices; space between gonapophyses very narrow, slightly widened at base; penis not curved upward from floor of genital chamber (Fig. 133), unmodified at apex. Basistyles moderately thick in smaller males to thick in robust males; posteromesal lobe of each prominent, evenly rounded, hairy. Dististyles (Figs. 131, 132) dark yellowish brown to dark brown, broad at base, with prominent, darkened, subacute mesal tooth, then abruptly narrowed, somewhat unevenly curved to narrowly rounded tip; darkly sclerotized ridge extending distad from mesal tooth; ventral tooth not present in specimens examined. Tenth segment rather evenly tapered from base toward apex, lightly sclerotized and pigmented laterally and ventrally.

Abdomen of female: Eighth tergum short (i.e., slender) dorsally, irregularly widened laterally but only to approximately one-third length of seventh, with three to five posterolateral setae. Hypovalves of eighth sternum subhyaline except for dark amber-colored margins, moderately deep for genus, with dorsal margin more or less straight or slightly concave, ventral margin tapering evenly toward dorsal for most of its length, then near apex sharply upturned to rounded tip (Fig. 135). Arms of genital furca slightly wider basally than apically, often pale (less darkly sclerotized) along one side or the other (Fig. 134); basal portion of furca longer than wide, not strongly sclerotized medially; entire structure lyriform. Ninth sternum formed by convergence of two slender, darkly sclerotized bands (Fig. 134) on upper surface of rounded projection, widened near attachment to furca (Fig. 136); acute point of convergence sometimes less densely sclerotized than rest of bands. Bursa copulatrix of large diameter, lightly sclerotized for much of its length (Fig. 42), with blackened swellings at bases of dorsal spermathecal ducts (visible through membrane between arms of furca). Cerci of medium length for genus, about 5-5.5 times as long as greatest width, thick, strongly curved upward in apical half, slightly widened just beyond mid-length, then narrowed to acutely rounded apex (Fig. 135); cerci about 1.2-1.4 times as long as hypovalve measured from notch to tip.

Types.—Holotype, female, Urbana (Champaign Co.), Illinois, in mouse nest, 11 December 1938, Philip C. Stone collector. Allotype, male, same locality as holotype, from nest of field mouse, *Microtus ochrogaster,* 16 December 1939, P. C. Stone. Paratopotypes: 1 ♀, from mouse nest, 12 January 1939; 1 ♂, 1 ♀, from mouse nest, 2 February 1940. The holotype, allotype and male paratype are mounted on microscope slides in the collection of Dr. C. P. Alexander, Amherst, Massachusetts. One female paratype in alcohol is in the collection of the Illinois State Natural History Survey, Urbana; the other is in the Museum of Comparative Zoology, Harvard Univ. I have examined all the types.

Variation.—Several individuals among the many examined had a single flagellomere beyond the fusion segment (Fig. 128); these were the one from Oklahoma, one male each from Iowa and Wisconsin, and two males, three females from near the type locality in Illinois. Some aspects of color variation have been included in the description, but a few others deserve mention here. When alive, *Chionea stoneana* has a decidedly sooty gray color, which may persist in specimens preserved dry. This leads me to wonder if the flies from Minnesota described by Ainslie (1906) as *C. valga* might not have been *stoneana.*

Since I have not been able to locate those specimens, and since the locality is reasonably within the range of both *valga* and *stoneana,* I have accepted his identification. Length of most males is in the range 4-5.5 mm, but one pinned specimen from Columbia, Missouri, is only 2.3 mm long, although somewhat shriveled, the abdominal segments "telescoped." In most males preserved in alcohol, the median region of the ninth abdominal tergum is a little paler than the rest of that segment, but in a few it was conspicuously paler, being almost yellowish brown and having the appearance of a median stripe. Teneral individuals preserved in alcohol are pale



Figs. 127-136, *Chionea stoneana.* 127, left antenna of male allotype, lateral aspect. 128, antenna of male from Oklahoma, showing single flagellomere beyond fusion segment. 129, posteromedian portion of ninth abdominal tergum, membranous tenth segment, and apices of gonapophyses, male, dorsal aspect. 130, posteromedian lobes of ninth tergum, left lateral aspect. 131, left dististyle, ventral aspect. 132, left dististyle, ventromesal aspect (more robust male than shown in Fig. 131). 133, right gonapophysis, penis, vesica and its apodemes and muscles, left lateral aspect (left gonapophysis removed). 134, genital furca and ninth sternum, female, ventral aspect (cleared, slide-mounted specimen). 135, terminal abdominal segments, female paratype, left lateral aspect. 136, details of ninth and tenth abdominal segments, female, ventrolateral aspect. Scales: a—127-134, 136; b—135.

tan, the integument so weakly pigmented that the muscles can be seen through it. The gonapophyses may taper evenly toward the apices, but in many males they have a more uniform width for most of their length, then narrow rather abruptly to acute tips. In the female, the expanse of the genital furca varies somewhat, and the intensity of sclerotization in its basal portion is highly variable, producing margins or other zones of lighter brown contrasting with the dark bases of the arms.

Relationships.—In defining the *valga* species group, near the outset of this report, I was obliged to stretch its limits somewhat to include *Chionea stoneana*. This was due primarily to the great reduction in the number of antennal segments in *stoneana* and *hybrida*, the other species in the group having five or more flagellomeres. The shape of the eighth abdominal tergum in the female of *stoneana* likewise is not in close conformity with that of the other species in this group. On the basis of the structure of the male gonapophyses, however, *stoneana* appears to belong in the *valga group*, this placement being supported by such details as the number of spermathecae and enlarged, sclerotized bursa copulatrix in the female and shape of the tenth segment in the male. The ninth abdominal tergum of the male most nearly resembles that of *C. nivicola* Doane, and neither of the two species has the ventral tooth on the dististyles; but the gonapophyses of *stoneana* are more like those of *valga* or *obtusa*. The pale, short, thick setae of body and especially legs suggest a relationship with *nivicola*, but the number and distribution of these on the femora and tibiae will serve to differentiate *stoneana* from all other species. I think that the resemblance to *Chionea alexandriana* and species in the *alexandriana* group on the basis of the antennae (cf. Alexander, 1940: 101) is only superficial and that the other characters of *stoneana* mentioned above more accurately indicate its relationships.

Geographic Distribution.—In the 40 years since the description of this species, it has never again been recorded, although it occurs in a region of considerable entomological activity. After discovering that at least some of Lugger's specimens from Minnesota were *stoneana* and not *valga* and then finding, among borrowed specimens, one from Norman, Oklahoma, I became convinced that the species must be widespread on the eastern plains, although possibly confined to wooded areas. I searched for it in Kansas in the winters of 1956 through 1960 and urged my students to watch for it. In the winter of 1960-1961, Mr. George Singer, to whom I had shown specimens of *Chionea* only a few days earlier, brought in three males of *stoneana* from Franklin Co., Kansas. The localities from which *stoneana* is now known are widely scattered and give only a suggestion of the range of the species, but I would expect to find it in the plains from Canada to northeastern Texas and eastward to Ohio, central Kentucky and possibly even in the Ozark Mountains of Arkansas (Map 3).

Seasonal Distribution.—The few available collection dates span the period from early November to early February, with records in all four months. Most specimens taken in early November are teneral. I am inclined to believe that there is but one generation a year and that the long season in this case reflects the longevity of the adults. The appearance of *Chionea stoneana* as far south as central Oklahoma at the earliest collection date is difficult to explain on the basis of my present concepts, unless 1926—the year of that collection—was unusually cold. However, as more data are gathered about the geographic and seasonal distribution of *stoneana*, this early, southern record may prove to be not at all unusual.

Habitats.—In Kansas, I found *Chionea*

stoneana in two apparently abandoned mouse nests situated in excavations beneath large, sawed sections of logs that had been lying on the ground for many months. The area had been partially deforested and was being used as a pasture. The woods were predominantly oaks, with some hickory and locust, and enough trees remained to have cast overlapping shadows on most of the ground during summer. The ground cover was grasses, various weeds of low to medium height, and some brush. Several logs were rolled over in the search for mouse nests or other cavities, but only the larger ones (about 20 in in diameter and, in these instances, 2-3 ft long) had been utilized as shelters by the rodents. Searching carefully under smaller logs, among dead leaves, in brush piles, etc., yielded no Chioneas, and none was seen on the ground, even near the nest logs. The mouse nests contained finely shredded, decayed wood, not unlike sawdust but the shreds a little coarser and more elongate, mixed with scraps of dead leaves, grass stems, and loose soil. The adult insects were mostly near the surface of this material, but digging down a few inches exposed additional individuals, as well as larvae in various instars. The temperature one inch below the surface of the nest material was 36°F, the air temperature 34°F. Other arthropods found beneath these nest logs included wood roaches, ants, *Myodocha* lygaeids, and a machilid, all scarcely able to move when exposed, and some small staphylinid beetles that were as active as the Chioneas.

As mentioned above, the type series of *stoneana* were all collected from mouse nests, including nests of the prairie field mouse, *Microtus ochrogaster* Wagner. The Minnesota specimens were found on the surface of snow, ". . . as far as observed only after a fresh fall of snow" (Lugger, 1896). Dr. Lugger also recorded that the flies were usually seen when the temperature was near freezing but that ". . . some have been found when it was below zero and the surface of the snow was frozen into a solid crust." There are several recent collections made by pitfall traps and Malaise traps, both effective in the absence of snow cover.

Collection Records.—ILLINOIS: Champaign Co., Urbana, in nests of mouse, *Microtus ochrogaster,* 11 Dec. 1938 (1 ♀, holotype), 16 Dec. 1939 (1 ♂, allotype), 2 Feb. 1940 (1 ♂, 1 ♀), all collected by P. C. Stone; Champaign Co., 2 mi N of Homer and 1.5 mi W of Route 49 bridge on Salt Fork of Vermilion River, 7 Nov.-2 Dec. 1972, in pitfall trap in oak-hickory woods, J. D. Unziker (8 ♂, 9 ♀); Clark Co., Rocky Branch, NE of Clarksville, 5 Feb. 1965, Rotrammel and Braasch (1 ♂); DeWitt Co., Allerton Park, 27 Dec. 1969, J. Bouseman and R. Selander (3 ♂); Jackson Co., Carbondale, on lighted window, 11 P.M., temperature 30-32°F, 24 Dec. 1960, J. C. Downey (1 ♂); Randolph Co., Fort Kaskaskia State Park, on snow, 15 Jan. 1964, L. J. Stannard (1 ♂). INDIANA: Clay Co., Posey Twp., in pitfall trap, old field, 23-26 Dec. 1974, J. R. Munsee (1 ♂, 1 ♀). IOWA: Boone Co., Ledges State Park, in oak-hickory leaf litter on ground near Pease Creek, 7 Nov. 1967, H. D. Blankespoor, L. C. Lewis and R. L. Jacques (3 ♂, 1 ♀, all teneral); Ledges State Park, 19 Jan. 1968, D. J. Kotzin (1 ♂, 1 ♀). KANSAS: Douglas Co., Breidenthal Reserve, Univ. of Kansas, 2 mi N of Baldwin, alive in pitfall trap, 20 Jan. 1973, G. W. Byers (1 ♂); Franklin Co., 14.5 mi S of Lawrence, from old mouse nests, 18 Dec. 1960, G. Singer (3 ♂); 2 Jan. 1961, G. W. Byers (14 ♂, 5 ♀). MINNESOTA: Ramsey Co., St. Paul (St. Anthony Park), December ("about Christmas"), O. Lugger (1 ♂, 1 ♀, and probably other specimens not seen). MISSOURI: Boone Co., Columbia, USDA Laboratory grounds, in Malaise trap, Feb. 1971, F. D. Parker (1 ♂, unusually small); Columbia, in Malaise

trap, 4 P.M.-7 A.M., 21-22 Dec. 1961, F. D. Parker (1 ♂, 1 ♀); St. Francois Co., Womack, 16 Jan. 1964, on snow, L. J. Stannard (1 ♀). OKLAHOMA: Cleveland Co., Norman, 11 Nov. 1926, M. J. Brown (1 ♂). WISCONSIN: Iowa Co., Clyde Twp., Sec. 12, from nest box CH3-1, 23 Dec. 1968, J. O. Jackson (1 ♂).

Chionea valga HARRIS

Chionea valga Harris, 1835: 595 (nomen nudum).

Chionea valga Harris, 1841: 404-405; Harris, 1852: 482; Harris, 1862: 601, Fig. 260; Osten Sacken, 1869: 168-170; Osten Sacken, 1878: 29; Lugger, 1896: 230-231 (in part *C. stoneana*); Ainslie, 1906: 275-276; Johnson, 1907: 41-43, with figs.; Washburn, 1907: 103; Needham, 1908: 207; Johnson, 1912: 102-104; Alexander, 1917: 207; Alexander, 1919: 805, 903; Treherne, 1920 (misidentified—*C. alexandriana*); Crampton, 1925: 204 ff., Fig. 9; Leonard, 1928: 694; Alexander, 1942: 429; Alexander, 1956: 177; Byers, 1961*a*: 190, Fig. 1; Byers, 1963: 160; Alexander, 1965: 72.

Chionea aspera Walker, 1848: 82; Alexander, 1919: 903.

Chionea gracilis Alexander, 1917: 206, Fig. 2; Alexander, 1919: 903; Leonard, 1928: 694; Alexander, 1942: 428-429.

Chionea noveboracensis Alexander, 1917: 205-206; Alexander, 1919: 903; Leonard, 1928: 694; Alexander, 1942: 429 (new synonymy).

Chionea waughi Curran, 1925: 24-26; Alexander, 1942: 429.

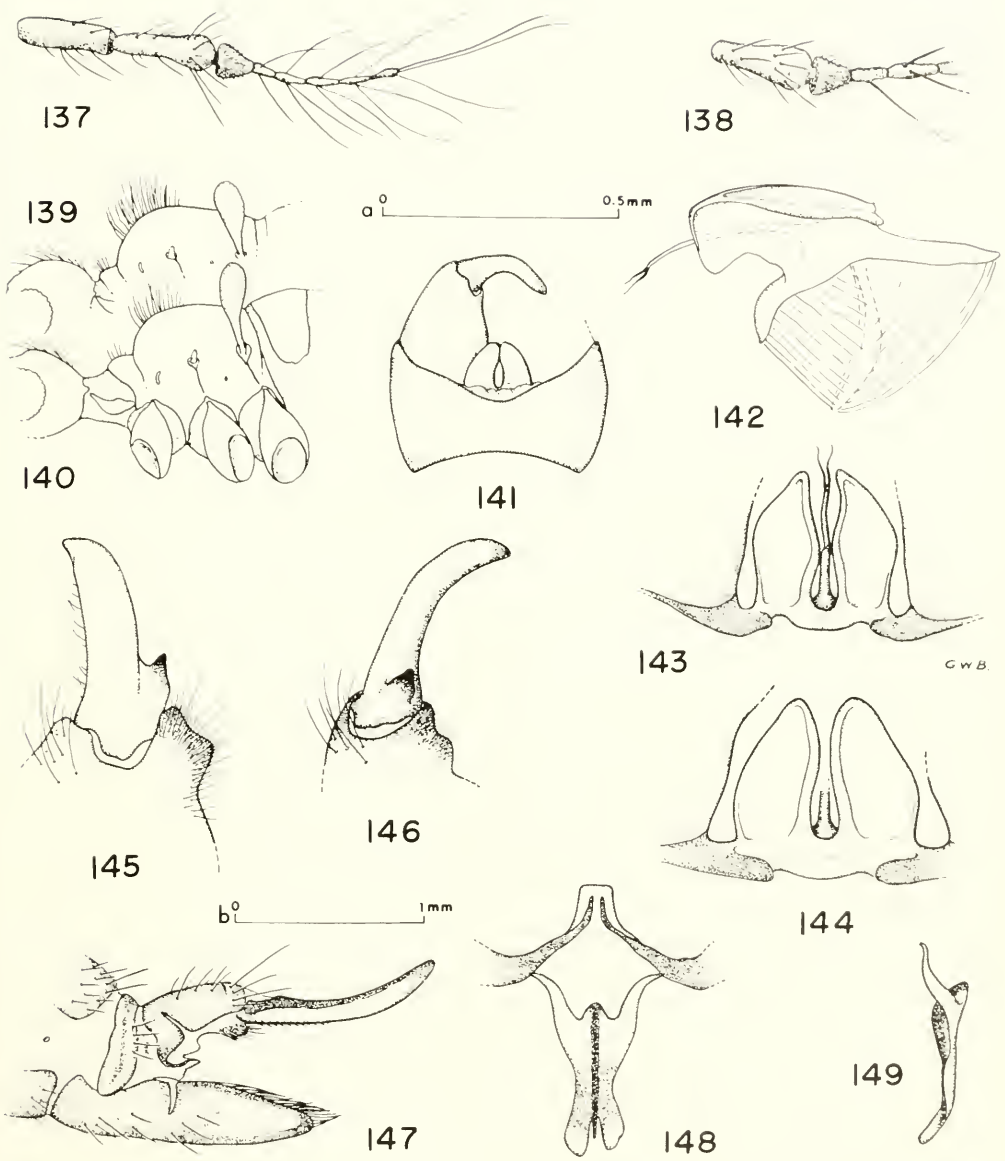
Diagnosis.—A northern and eastern species of dull reddish brown to grayish brown color, with antennae of seven or eight segments; male gonapophyses, seen from above, broad, shallowly concave, blade-like, with concealed, deep ventral keel; female cerci slightly widened and upturned beyond mid-length, then tapered to acute apex; median portion of ninth sternum weakly sclerotized, truncate apically.

Description.—General appearance of specimens preserved in alcohol: head dark reddish brown, thorax and abdominal sclerites reddish brown to brown, except ninth segment of male dark reddish brown; membranous areas paler brown; cerci of female dark amber-brown. Specimens preserved dry (on pins) more grayish brown in color. Length of male about 3.5-6.0 mm, female about 4-8 mm, excluding antennae.

Head: Antennae (Fig. 137) with pedicel slightly longer than cylindrical scape; fusion segment subconical, asymmetrical, about as long as its basal diameter; four or five additional flagellomeres. Setae on vertex dark brown, stout. Eyes each with about 100-130 ommatidia.

Thorax: Dorsum mostly reddish brown to brown, darkening unevenly to sides, on pronotum and on metanotum. Mesonotum in both sexes conspicuously "humped" in lateral aspect, with anterior slope nearly perpendicular to pronotum (Figs. 139, 140). Setae on mesonotum numerous, long, erect. Halteres grayish brown, contrasting with color of thoracic dorsum but not conspicuously so. Legs of moderate length, with hind femora extending only approximately to end of abdomen; femora light reddish brown to dark yellowish brown, their setae long, attenuate at tip, brown, not in readily discernible rows in males, usually in four dorsal, three ventral rows in females. Tibiae and basitarsi same color as femora, with almost equally long, slender setae; tibial setae of females and of fore and middle legs of males generally in longitudinal rows, more randomly distributed on hind legs of males. Tarsomeres beyond basitarsus darkening to brown.

Abdomen of male: Tergal setae long, pale, sparse, chiefly near posterior margins of terga. Sternal setae longest and most dense at sides of sterna, with a few along posterior margins. Posterodorsal margin of ninth tergum (Fig. 141) with widely U-shaped emargination, without lobes but with scattering of submarginal setae; emar-



FIGS. 137-149, *Chionea valga*. 137, right antenna of male, approximately dorsal aspect (slide-mounted). 138, basal portion of left antenna, male from Michigan (J. S. Rogers slide 2848), showing subdivision of basal flagellomere. 139, thoracic dorsum of male, left lateral aspect, to show abrupt slope of mesonotum. 140, thorax of female, left lateral aspect; compare with *C. obtusa*, Figs. 123, 124. 141, ninth abdominal segment of male, dorsal aspect (left basistyle and dististyle omitted, tenth segment pushed inward to expose gonapophyses). 142, right gonapophysis and penis, male from Wisconsin, right lateral aspect. 143, gonapophyses and penis, male from New Hampshire, dorsal aspect. 144, gonapophyses, male from Minnesota, dorsal aspect. 145, left dististyle, male from Wisconsin, ventral aspect (somewhat foreshortened because of curvature). 146, left dististyle, ventromesal aspect. 147, terminal abdominal segments, female from Michigan, left lateral aspect. 148, ninth sternum and genital furca, female from Vermont, posteroventral aspect. 149, genital furca, left lateral aspect. Scales: a—137-138, 142-146, 148-149; b—139-141, 147.

gination so wide and shallow as to give impression of entire margin in certain aspects. Gonapophyses in dorsal aspect (Fig. 144) broad, nearly oval, narrowest at rounded apex, with upturned mesal and lateral margins producing central concavity; mesal margin noticeably thickened; in lateral aspect (Fig. 142) deeply keeled, posterior end of keel deepest. Apex of penis with two slender, elongate filaments (Fig. 143). Basistyles each with rounded, pilose posteromesal lobe; dististyles (Figs. 145, 146) dark reddish brown, with prominent, acute, blackened mesal tooth; ventral tooth absent. Proctiger (tenth segment) membranous, pale, evenly narrowed toward rounded apex, extending approximately to tips of gonapophyses.

Abdomen of female: Setae of terga and sterna pale, more dispersed over sclerites than in male. Eighth tergum (Fig. 147) expanded at sides to more than half length of seventh tergum, shorter dorsally, with darkened, transverse line or zone near mid-length and with three or four marginal setae. Hypovalves extending to about mid-length of cerci, with upper margin slightly sinuate, lower margin straight near base, then curved upward toward narrowly rounded apex. Arms of genital furca (Fig. 148) relatively thick at base, slender in apical half, often more strongly divergent basally than apically, with nearly angular deflection near mid-length; base with divergent apodemes; darkened median portion of bursa copulatrix adjacent to furca visible through membrane in posterior aspect (or in cleared, slide-mounted specimens). Mid-ventral portion of ninth sternum (Fig. 148) not strongly sclerotized, somewhat trapezoidal in shape. Cerci about 1.3-1.4 times length of hypovalves (measured from notch to tip), upturned and slightly widened beyond mid-length (Fig. 147), with sharply rounded or acute apex.

Types.—Holotype, female, labelled only "174. ♀" and "M.C.Z. Type 26398," in the Museum of Comparative Zoology, Harvard Univ. This pinned specimen is considerably shriveled, with the abdominal sclerites telescoped. A label near the specimen reads "*Chionea valga* Harris Type." Mr. Norman Woodley found a catalogue of Thaddeus Harris' collection in the archives of the Museum of Comparative Zoology, and after the number 174 the entry "Dublin, N. H., Mr. Leonard." He also found a list of specimens entitled "Insects for Mr. Say, from T. W. Harris," on page 20 of which the number 174 is followed by "*Chionea valga,* mi. Mss. N. Hamp. 4." The type, therefore, although recorded from Massachusetts (i.e., in "A Report on the Insects of Massachusetts"), is apparently one of an original series of four or more from New Hampshire. I am indebted to Mr. Woodley for this help.

Chionea aspera Walker was based upon three males and one female, one male of which I have selected as lectotype (Byers, 1963: 160). The synonymy of this name with *C. valga* has long been asserted (first by Osten Sacken, 1869: 168), and examination of the types of *aspera* satisfied me that this synonymy is correct.

Osten Sacken had, in fact, commented on the probable synonymy of *aspera* and *valga* some years prior to the 1869 publication mentioned. The Report on the Insects of Massachusetts, containing Harris' description of *C. valga,* had a second edition in 1852 and a third in 1862. In the third, the 1841 description was repeated and a woodcut of the insect was added (Fig. 260). The following footnote by Osten Sacken also appeared on p. 601: "Mr. Walker has described two American species of this singular genus; one of them, *Chionea aspera,* seems to be identical with Dr. Harris's *C. valga.* I do not undertake to decide which name should be preferred. Dr. Harris's has the priority, but the few words he mentions about his insect can hardly be called a description. . . ." The lectotype male of *aspera,* from "Hudson's

Bay," is missing the middle leg on both sides but is otherwise intact; it has four flagellomeres beyond the fusion segment.

Chionea gracilis Alexander was based upon a single male specimen, differentiated from *valga* by being smaller (3.9 mm long) and slender, without incrassate femora. In these characters, however, this individual falls easily within the limits of variation of *C. valga*. The holotype, mounted on a microscope slide, is badly shriveled and misshapen, but some of the essential taxonomic details can be seen. I judge this to be an extraordinarily teneral specimen, so callow that it appears to have been mounted without being first cleared, for the digestive system, Malpighian tubules, central nervous system, and muscles of body and appendages are still plainly visible. The gonapophyses and sclerotized portions of the internal genitalia indicate the identity of the specimen, even though both antennal flagella are missing, most of the body hairs have been broken off, and the ninth abdominal tergum is badly distorted.

Chionea noveboracensis Alexander was also described from one specimen, a small female (3.5 mm long), said to differ from *valga* in being gray instead of reddish. The holotype, originally returned to R. C. Shannon, the collector, has been lost so could not be examined by me. However, I have seen two males and a female in Dr. Alexander's collection, determined by him as probably being his species *noveboracensis*, and these are, without question, all *C. valga*. Grayish pruinosity or even grayish body color are often seen in *valga*, so I am inclined to discount that one stated difference between the two forms. It furthermore seems to me that if there were in New York, in an area of considerable entomological activity such as the type locality of *noveboracensis*, some other species than *valga* and *scita*, it would have turned up again during the many years since *noveboracensis* was described.

Chionea waughi Curran was said to be ". . . most closely allied to *C. valga* but is readily distinguished by the absence of a wide projection on the upper margin of the basal portion of the genitalia and the long antennal flagellum." Just what the "wide projection" is that is absent in *waughi* and present in *valga*, I cannot be sure; perhaps it is the margin of the ninth tergum, or possibly Curran was referring to the membranous tenth segment, which in the holotype of *waughi* has become shriveled, exposing the gonapophyses. The described antennal difference is non-existent, seven segments being a common number in *valga*. Curran described *waughi* from three males and a female. I have examined the male holotype, female allotype and one of the male paratypes and am confident that these are the same as *Chionea valga*.

Variation.—Size variation in this species has been described earlier in the section on external morphology of adults. Some individuals of *C. valga* may be twice as long as others of the same sex taken on the same day in the same habitat; but dimensions of the genital segments vary much less than those of body and legs.

Antennae with four flagellomeres beyond the fusion segment are found in 96% of individuals in a Minnesota population, with 4% having five slender flagellomeres. Among specimens from Montmorency Co., Michigan, in contrast, 42% have five segments beyond the conical fusion segment. In some other samples the two forms are about equally common. One specimen from Michigan has a very short flagellomere just beyond the fusion segment, then five others. Another shows the second flagellomere distinctly subdivided into five non-articulated annuli (Fig. 138, from slide no. 2848, Univ. of Michigan collection).

Due to twisting toward the sides, the gonapophyses may appear more acutely tipped (Fig. 143) than they normally are in dorsal aspect (Fig. 144). In slender

males the gonapophyses are usually separated throughout their length, but when robust males are preserved their thick basistyles may push the tips of the gonopophyses together (Fig. 141).

The upper margins of the hypovalves of the ovipositor vary from slightly and evenly convex to sinuate (slightly convex near the base, then very shallowly concave before the apex). There is much variation in details of the shape of the genital furca, but the dark axis, the relatively thick, short arms and the bifurcate anterior end are constant.

Relationships.—In overall appearance as well as in numerous details, *C. valga* most closely resembles the western *C. obtusa*. The similarity includes the abundant, long, thin hairs of legs and body, the general shape of male gonapophyses and dististyles, the genital furca of the female, and antennal length. In eastern North America, east of the Rocky Mountains, *valga* requires only to be differentiated from *scita* and *stoneana*, with which it sometimes is found. This is an easy matter, for *valga* and *scita* differ conspicuously in color and antennal length, and *valga* has longer setae on the legs and two or three more flagellomeres than *stoneana*. But at least in the vicinity of Edmonton, Alberta, *valga* appears to reach the range of the closely related *obtusa*. Males of these two species may be differentiated by details of the gonapophyses (for example, the outer edges are thicker and more strongly upturned in *valga;* compare Figs. 143 and 117), and by the evenly and shallowly emarginate, virtually entire ninth tergum in *valga* (Fig. 141) contrasted with the distinctly notched tergum in *obtusa* (Fig. 118). The terminal filaments of the penis in *valga* are not present in *obtusa;* however, this characteristic is independent of others elsewhere in the genus, such as being present in *albertensis* but not *scita*.

Females of *valga* are much easier to tell apart from those of *obtusa* than are males because of the conspicuous difference in their cerci (cf. Figs. 147 and 125) and to a lesser extent their hypovalves.

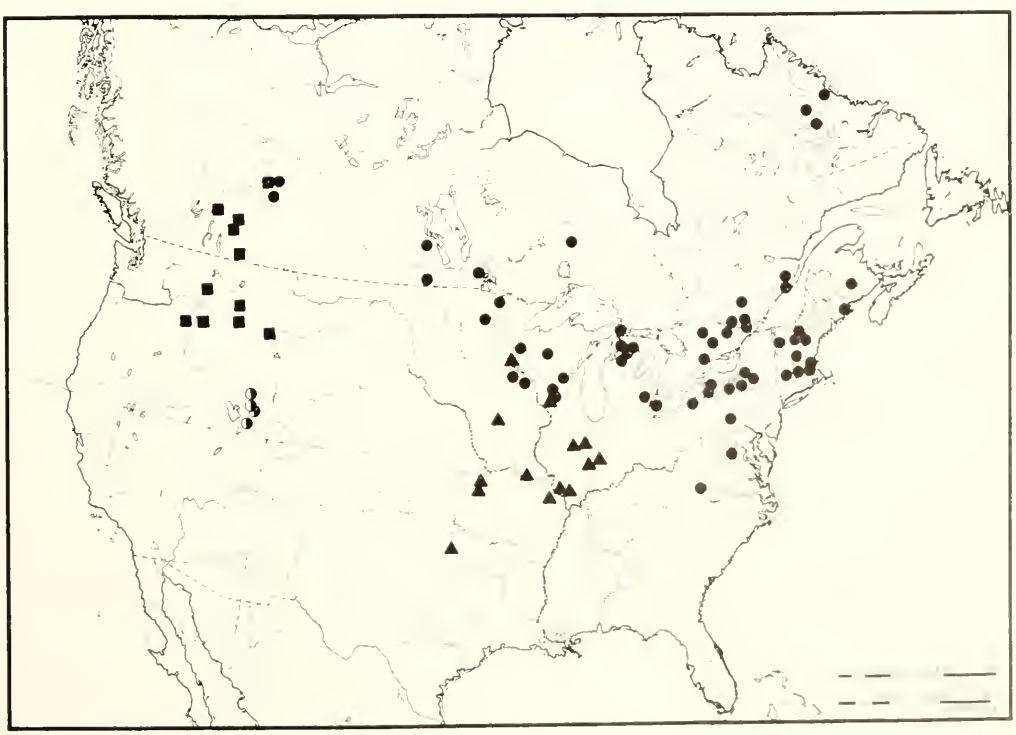
In both sexes the lateral profile of the mesonotum will serve to differentiate these species. The mesonotum is much more conspicuously "humped" in *valga* (Figs. 139, 140), its anterior surface nearly perpendicular to the pronotum. In *obtusa* the anterior slope of the mesonotum is much less abrupt (Figs. 123, 124). There are occasional individuals in which this difference is not as distinct as I have illustrated it; some robust males of *obtusa* approach the condition seen in *valga*, and some small, slender individuals of *valga* approach the *obtusa* profile. The described difference, however, is probably 98% reliable.

Geographic Distribution.—Chionea valga is the most widely distributed species in the genus, ranging from coastal Labrador westward to central Alberta and to Minnesota and southwestward along the Appalachian Mountains to southern Virginia (Map 3). This range spans 19 degrees of latitude and nearly 55 degrees of longitude and includes elevations from near sea level to about 925 m (3000 ft). Alexander (1942: 429) recorded the species from Saskatchewan; I have not seen specimens from that province but do not question the record, as *valga* extends westward into Alberta, where it apparently contacts the range of the very similar *C. obtusa*. It is a little surprising that there are so few records from Pennsylvania and Maine, particularly the former. I anticipate that *C. valga* will be found in southeastern Ohio, West Virginia, western Maryland, and further south in the Appalachian Mountains.

Seasonal Distribution.—There are collection records for every ten-day period from 10 November to 10 April, with numerous collections throughout December-March. At the northernmost locality, Voisey's Bay, Labrador (Newfoundland),

valga is still present in early May. The September and October records, however, are not from particularly far-northern sites (Manitoba and New York). A conspicuous peak in the numbers of collections occurs in the last week of December, but this probably relates to the holiday season when many entomologists and other naturalists are away from school or work and into rural areas for skiing or the like. There is no evidence of more than a single generation per year; if there were two generations, their peaks might be obscured by the long individual life of the insects and by emergence delayed by unfavorable weather.

Habitats.—The broad range of *C. valga* includes a number of general types of habitat. Roughly from north to south these are: arctic tundra in coastal Labrador; subarctic spruce forest and more southern subarctic spruce-fir forest extending across much of southern Canada; white pine, jack pine and other evergreens in the northern Great Lakes region; and mixed hardwood forest of beech, maple, hemlock, birch, etc., from the upper Mississippi River eastward across Wisconsin, Michigan, New York, Pennsylvania and much of New England and extending southward along the crest of the Appalachian Mountains. Elsewhere the species penetrates to a limited extent the oak-hickory forest and the Appalanchian hardwood forest. The role of these major kinds of vegetation in the ecological distribution of *C. valga* is not clear, however. The range in general has fairly deep and persistent snow cover from November through March, with forest vegetation providing protection from wind and wind-blown snow as well as access to the snow surface. Nearly all specimens with habitat data were taken on snow or in pitfall traps of one sort or



Map 3. Ranges of species of the *Chionea valga* group: *Chionea valga* (solid circles), *C. obtusa* (squares), *C. stoneana* (triangles) and *C. hybrida* (half-blackened circles). Each symbol represents one or more collections within a county (in the United States) or at a locality.

another; but two from Mifflin Co., Pennsylvania, were collected in a cave, in April.

Collection Records.—ALBERTA: Edmonton, 3 Dec. 1927 (1 ♀), 15 Dec. 1926 (1 ♂, 1 ♀), 29 Dec. 1926 (1 ♀), all collected by E. H. Strickland; Rimbey (32 mi NW of Red Deer, about 52°37′N, 114° 14′W), 22 Oct. 1929 (1 ♀). LABRADOR: Tessiuyakh Bay (56°14.9′N, 62°1.9′W), elevation 25 ft, on snow in mild weather, 5 May 1951, E. P. Wheeler (4 ♂); Voisey's Bay (same locality as Tessiuyakh Bay), on snow, 5 Dec. 1921, F. W. Waugh (3 ♂, holotype and paratypes of *C. waughi*); Cabot Lake (about 54°40′N, 64°20′W, labelled Labrador but actually in adjacent Quebec), Sept.-Oct. 1921, F. W. Waugh (1 ♀, allotype of *C. waughi*). MAINE: Washington Co., Woodland, 11 Jan. 1916 (1 ♂, 1 ♀); same, but 1 Dec. 1917 (1 ♂, 1 ♀); both collected by Olaf Nylander. MANITOBA: Aweme (20 mi SE of Brandon, about 49°37′N, 99°35′W), on boggy ground, ambient temperature "below zero," 12 Sept. 1910 (1 ♀); same locality, 27 Nov. 1917 (1 ♀), 12 Dec. 1924 (1 ♂); Dauphin vicinity (about 51°10′N, 100°00′W), March 1919, Mrs. Hippisley (1 ♂); Whiteshell, Red Rock Lake, 23 Feb. 1970, W. O. Pruitt (1 ♂, 1 ♀). MASSACHUSETTS: Berkshire Co., Monterey (labelled Monterrey), Jan. 1951, J. D. Miner (1 ♂); Essex Co., Andover, 1 Jan. 1874, F. C. S. (1 ♂); Hampshire Co., Amherst, 19 Feb. 1929 (1 ♂), 12 Dec. 1926 (1 ♂), Orient Springs, 3 Feb. 1929 (1 ♀), all collected by C. P. Alexander; Cummington, elevation 1400 ft, crawling on snow in snow storm, 2 Jan. 1932 (1 ♂); same locality, 5 Jan. 1946 (3 ♂, 3 ♀); same, on snow in open pasture, 1 Feb. 1946 (2 ♀); same locality, 20 Dec. 1932 (1 ♀); all collected by A. B. Gurney; Middlesex Co., Sherborn, 15 March 1925, C. A. Frost (1 ♂); Framingham, 19 Jan. 1917, C. A. Frost (1 ♂); Malden (1 specimen; see Johnson, 1912); Tyngsboro, 6 Dec. 1911, J. H. Emerton (1 ♂); same, no date, Blanchard collector (1 ♂, 1 ♀). MICHIGAN: Cheboygan Co., Reese's Bog (north shore Burt Lake), on surface of snow, 23 Feb. 1952, W. O. Pruitt (1 ♀); same, 24 Feb. 1952 (2 ♂); Chippewa Co., Chase Osborn Preserve, Sugar Island, on snow, air temperature 0°C, 20 Dec. 1949, W. O. Pruitt (1 ♂); Crawford Co., near Lovell's, 11 Jan. 1936, J. W. Leonard (1 ♂); Montmorency Co., Hunt Creek Station (a laboratory for fisheries studies), 13 Jan. 1942 (9 ♂, 5 ♀), 29 Jan. 1941 (1 ♀), 2 Feb. 1941 (2 ♂, 1 ♀), 5 Feb. 1942 (1 ♀), 6 Feb. 1942 (2 ♀), 12 March 1942 (1 ♀), 8 Dec. 1942 (3 ♂, 1 ♀), 31 Dec. 1941 (1 ♀), all collected by Justin W. Leonard; Oakland Co., Wixom, Proud Lake State Recreation Area, walking on snow in red pine woods, overcast, 8°C, near Huron River, 13 Jan. 1979, T. L. Heller (1 ♂); Presque Isle Co., Lake Huron (T37N, R2E, Sec. 14), on ice, 50 yards from shore, 23 Feb. 1952, Erna Pruitt (1 ♂); on ice on Palestri's Creek, 22 Feb. 1952, Erna Pruitt (1 ♂). MINNESOTA: Clearwater Co., Itasca State Park, 22 March 1979 (2 ♀); Dakota Co., in pit traps (baited with 4% formalin or 50% wine) under 12-19 cm snow, 6-18 Jan. 1972, Owen Marshall (13 ♂, 5 ♀); same, but 18 Jan.-1 Feb. 1972, snow 12-36 cm deep (1 ♂, 6 ♀); same, but 8-15 Feb. 1972, snow 17-33 cm deep (1 ♂, 2 ♀); Koochiching Co., Big Falls, 26 March 1971 (1 ♀); Olmstead Co., Rochester, on snow 1 ft deep, 15°F, 25 Dec. 1905 (1 ♂); same, 27 Dec. 1905 (1 ♂, 1 ♀) (not seen; both reported by Ainslie, 1906). NEW BRUNSWICK: Fredericton, 21 Dec. 1929 (1 ♂); York Co., Hanwell Road, on snow, 1 Feb. 1970 (1 ♀). NEW HAMPSHIRE: Carroll Co., Jackson, on snow 2-3 ft deep, in sheltered places at edge of woods, 20 Feb. 1907, J. H. Emerton (3 ♂, 1 ♀); Cheshire Co., Jaffrey, 4 March (1 ♀); Coos Co., Jefferson, 23 Feb. 1970, O. S. Flint, Jr. (4 ♂, 2 ♀); Mt. Clinton (2 mi NE of Crawford House, Crawford Notch), in forest, 45°F, 30 Jan. 1970, S. Peck (1 ♂);

White Mts., on snow, Jan. 1969, S. Peck (2 ♂); Grafton Co., Mt. Lafayette, 8 mi N of Lincoln, 3000 ft, on deep snow, 18 Jan. 1969, S. Peck (1 ♂); Hanover and vicinity, 31 Dec. 1960 (1 ♂, 1 ♀), 8 Jan. 1961 (1 ♀), 26 Dec. 1961 (1 ♀), 23 Dec. 1962 (2 ♂, 1 ♀), 31 Dec. 1962 (1 ♂), 5 Jan. 1963 (2 ♀), 24 Dec. 1963 (2 ♂, 1 ♀), all collected by K. W. Cooper. NEW YORK: Cattaraugus Co., Otto, 18 March 1896, J. H. Comstock (1 ♀); Chenango Co., Bainbridge, 15 Dec. 1922, L. J. W. Jones (1 ♂); Erie Co., Lancaster, no date, M. C. Van Duzee (1 ♂); Onondaga Co., Manlius, 1 Oct. 1872 (1 specimen, not seen; see Needham, 1908: 207); Steuben Co., Lake Keuka, Dec. 1905 (1 ♂, 1 ♀); Tompkins Co., Buttermilk Falls State Park, on snow, 29 Dec. 1966 (2 ♂); Enfield Glen (Enfield Falls), 21 Feb. 1920, S. Emerson (1 ♂); Coy Glen, elevation 800 ft, 25 Feb. 1917, R. C. Shannon (1 ♀, type of *C. noveboracensis,* not seen); Ithaca, 15 Dec. 1907 (1 ♂, type of *C. gracilis;* published collection date 21 Dec. 1914); also the following reported from Tompkins Co. by Needham (1908: 207) but specimens not seen: Ithaca, 15 March 1896 and 15 Nov. 1892, Forest Home, Dec. 1907. ONTARIO: Carleton Co., Ottawa, on snow, 23 Dec. 1924, G. H. Hammond (1 ♀); Essex Co., 1 Jan. 1936, C. A. Neil (1 ♀); Nipissing Co., Algonquin Park, 29 Dec. 1951, F. P. Ide (3 ♂, 2 ♀); Hastings Co., Graphite Lake, near Maynooth, on snow, 18 Nov. 1967, J. E. H. Martin (1 ♀); Ontario Co., 1 Feb. 1941, F. A. Urquhart (3 ♂, 5 ♀); Renfrew Co., Arnprior, temperature 20°F, 11 Jan. 1920, C. Macnamara (1 ♂, 1 ♀); same locality, 13 Feb. 1920 (1 ♂); Thunder Bay District, St. Martin's Falls, Albany River, no date (3 ♂, 1 ♀, types of *C. aspera*); York Co., Humber River, 13 Jan. 1952, F. P. Ide (1 ♀). PENNSYLVANIA: Erie Co., Edinboro, Conneauttee Creek tributary, 1465 ft, in emergence trap, on snow, –4°C, 18 Feb. 1980, Becky Travis (1 ♀); same locality, 15 Jan. 1981, B. Travis (1 ♂); Mifflin Co., Aitken Cave, 4 April 1937, K. Dearolf (1 ♂, 1 ♀). QUEBEC: Gatineau Co., Aylmer (7 mi SW of Hull), on snow, 20 and 24 Dec. 1938 (2 ♂); Gatineau National Park, near Hull, Lake Phillip, on snow, 29°F, 29 Nov. 1970, S. Peck (1 ♀); Camp Fortune, at Old Chelsea (6 mi NW of Hull), on snow, 18 Feb. 1951 (1 ♂) and 4 March 1951 (1 ♂); Old Chelsea, 22 Jan. 1967, D. M. Wood (2 ♀); Gatineau Park, near Old Chelsea, 22 March 1970, L. Masner (1 ♀); Lac Roddick, 16 mi S of Maniwaki, on snow, 24 Feb. 1980, L. Harner (1 ♂); Quebec, Mont Ste. Anne, 12 Mar. 1978, J. R. Vockeroth (2 ♂, 3 ♀); Laurentide Prov. Park, Camp Mercier, 36 mi N of Quebec, 23 Feb. 1975, F. Brodo (10 ♂, 6 ♀); Indian House Lake (56°08′N, 64°44′W), elevation 1000 ft, 22 Nov. 1944, R. C. Clement (specimens not seen). VERMONT: Chittenden Co., 3 mi N of Bolton (Middle Bryant Lodge), elevation above 2000 ft, on deep snow in yellow birch woods, 23 Jan. 1955, Rodger Mitchell (26 ♂, 19 ♀). VIRGINIA: Giles Co., Cascades Trail (near Pembroke), in fine, loose litter in hollowed base of tree, about 2 in snow on ground, 7 Jan. 1981, J. A. Vaughan (1 ♂); Warren Co., Shenandoah National Park, Dickey Ridge (north end of Park), on snow, 17 Feb. 1970, O. S. Flint, Jr. (1 ♀). WISCONSIN: Burnett Co., 11 mi E, 4 mi S of Siren, on snow, 1 Feb. 1970, D. Hansen (1 ♂, 1 ♀); Iowa Co., Clyde Twp., Sect. 12, on snow, north-facing slope, Dec. 1967 (1 ♂); Price Co., walking on snow, 21 Jan. 1979 (1 ♂, 2 ♀); Sauk Co., Otter Creek, on snow along stream bank, 8 Feb. 1969, R. P. Narf (1 ♀); same, but 7 Jan. 1967 (1 ♂); same, but 27 March 1967 (1 ♀); Parfrey's Glen, T11N, R7E, Sect. 25, 7 Jan. 1967, R. P. Narf (3 ♀); same, but Sect. 22-23, 13 March 1965 (1 ♀); same, but 14 March 1965, J. K. Lawton (1 ♀); Waushara Co., Bird Creek, T18N, R10E, Sect. 3, Hwy. 21 bridge, 9 Feb. 1967 (1 ♀).

THE C. alexandriana GROUP

A western montane group of species. Body color brown, with evident pattern on abdominal terga in some species, dark brown or black; antennae with two to four flagellomeres beyond fusion segment; gonapophyses of male with upturned, often hook-like apical point, usually broad at base and conspicuously narrowed toward apex, in dorsal aspect; eighth abdominal tergum of female short, much less than half length of seventh tergum; median portion of ninth sternum a sclerotized plate, often with three posterior lobes or teeth. Included species: *alexandriana* Garrett, *carolus* Byers, *durbini* new species, *excavata* new species, *jellisoni* new species, *lyrata* new species and *nigra* new species.

Chionea alexandriana GARRETT

Chionea alexandriana Garrett, 1922: 62-64, Figs. 6-11; Alexander, 1965: 72.

As *Chionea valga*: Treherne, 1920: 201-202 (misidentification).

Diagnosis.—A dark brown, western, primarily montane species; antennae with three to four flagellomeres; male gonapophyses slender and hooked at apex, dististyles smoothly rounded dorsally; female cerci slender, upturned in distal half, noticeably longer than hypovalves.

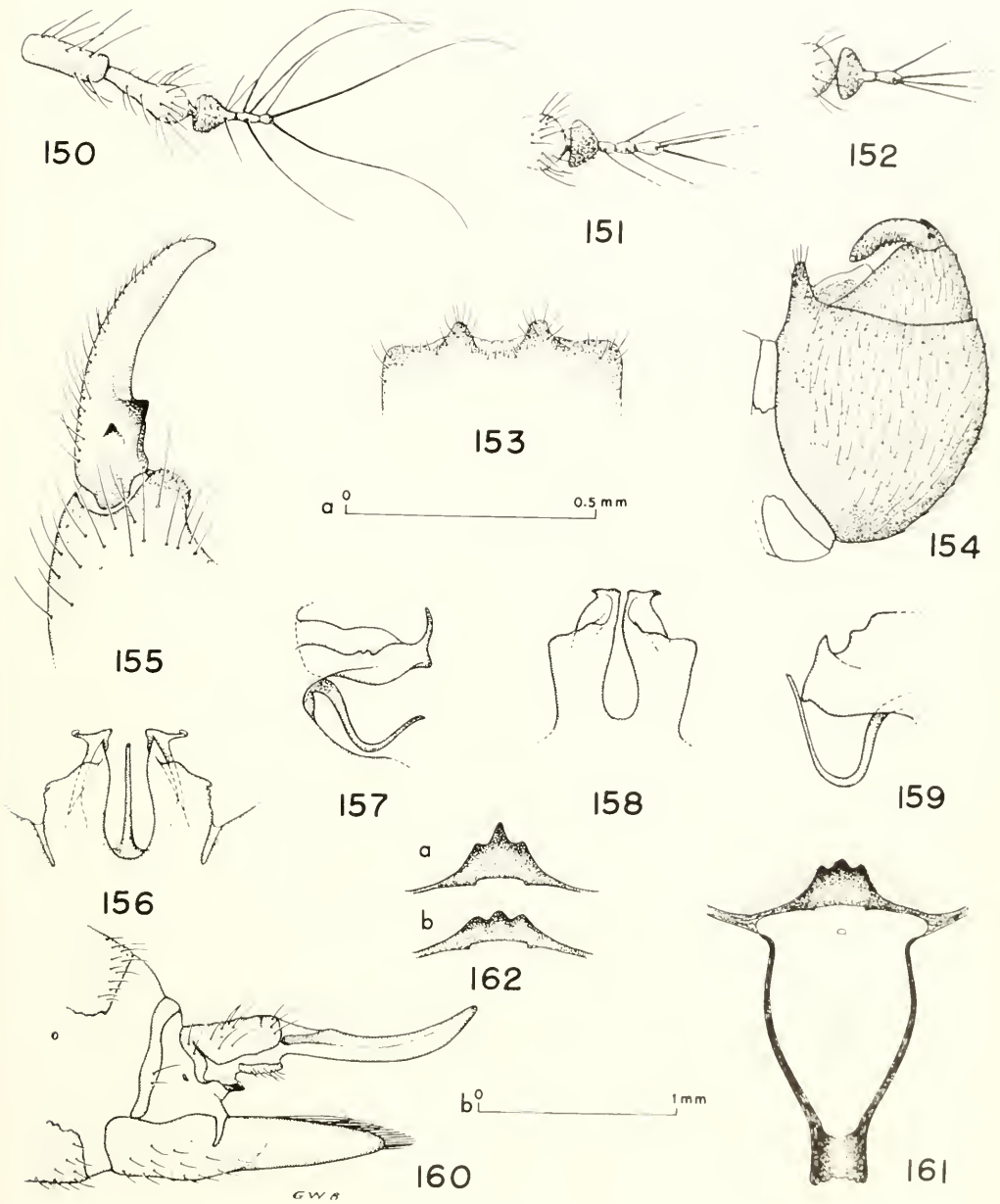
Description.—General appearance: Head dark grayish brown, thorax dark brown; abdominal sclerites light brown to brown, terga darker brown anteriorly, along midline and at lateral edges; ninth segment of male dark grayish brown, cerci of female amber-brown; pleural membranes grayish tan. Length of male about 4-8.3 mm, female about 4-8 mm, exclusive of antennae.

Head: Antennae (Figs. 150-152) comprising scape, pedicel, and usually three, not uncommonly four flagellomeres; fusion segment short, turbinate to subconical, its apical portion sometimes resembling an additional short segment. Eyes with about 110-120 ommatidia each.

Thorax: Halteres pale grayish brown (in alcohol) to yellowish brown (dried), contrasting with color of thoracic dorsum. Legs dark brown to dark reddish brown; seven (4 dorsal, 3 ventral) to 11 longitudinal rows of setae on femora, in males sometimes additional hairs not in rows; second and succeeding tarsomeres blackish brown to black.

Abdomen of male: Posterodorsal edge of ninth tergum (Fig. 153) with a broad, shallow median emargination; a small, thick lobe bearing six to eight setae at each side of emargination. Gonapophyses (Figs. 156-159) broad at base, narrowing abruptly near mid-length; apical portion hook-like, with prominent, angular ventral process, slender, curved upward to acute tip; space between gonapophyses narrowly U-shaped, or slightly narrowed caudally, less often constricted near posterior end; apex of penis unmodified. Basistyles moderately thick for genus to thick in large males; posteromesal lobe of each pilose, sometimes with two rounded protuberances. Dististyles (Fig. 155) dark brown, thick, with prominent, blackened, subacute mesal tooth at base, then abruptly narrowed, more or less circular in cross-section, and evenly tapered to apex; ventral tooth usually small, in some large males darkly sclerotized but not strongly developed. Tenth segment broad at base, narrowed near mid-length, pigmented and lightly sclerotized laterally.

Abdomen of female: Eighth tergum short (i.e., slender) throughout. Hypovalves of eighth sternum comparatively slender, dorsal margin sloping downward toward apex, ventral margin curving upward, producing subacute apex. Arms of genital furca slender apically, slightly thickened near base (Fig. 161); basal portion about as wide as long, weakly sclerotized medially. Mid-ventral portion of ninth sternum (Figs. 161, 162a,b) well



FIGS. 150-162, *Chionea alexandriana*. 150, left antenna of male, mesal aspect. 151, 152, antennal flagella of females from Alberta, showing variation in number of flagellomeres (in 152, one of the four setae arises on the fusion segment). 153, ninth abdominal tergum, male, dorsal aspect. 154, genital segment of robust male, left lateral aspect. 155, left dististyle, ventral aspect. 156, gonapophyses and penis, dorsal aspect. 157, same, left lateral aspect. 158, 159, gonapophyses of atypical male from ice cave in Oregon. 160, terminal abdominal segments, female, left lateral aspect. 161, ninth sternum and genital furca, female, ventral aspect. 162a, b, variations in median portion of ninth abdominal sternum. Scales: a—150-153, 156-159, 161-162; b—154-155, 160.

sclerotized, with three blunt teeth, middle one longest; a rounded, lightly sclerotized area above and to each side of darkened portion. Cerci elongate, about 6-6.5 times as long as greatest width, curved upward in apical half, noticeably longer than hypovalves (about 1.2-1.4 times as long as hypovalve measured from notch to tip).

Garrett's (1922: 63) illustrations do not adequately portray the structural details he intended to show; they are, in fact, rather grotesque caricatures.

Types.—Holotype, male, Cranbrook, British Columbia, elevation 3500 ft, 22 February 1921, C. B. D. Garrett collector. Allotype, female, and two female paratypes, same data as holotype. Additional paratypes: 1 ♀, type locality but collected 13 February 1920; 1 ♀, Canal Flats, Kootenay Valley, British Columbia, March or April 1921. Holotype, allotype and Kootenay Valley paratype in collection of Mr. C. B. D. Garrett, Cranbrook, British Columbia. One paratype each sent to Dr. C. P. Alexander, Amherst, Massachusetts, United States National Museum, Washington, D.C., and Canadian National Collection (Canada Department of Agriculture), Ottawa, Ontario.

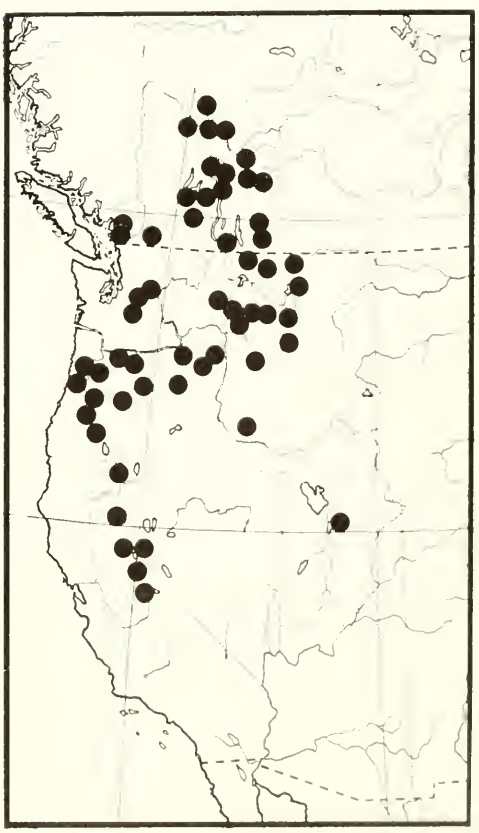
Variation.—In a series of 15 males and 17 females from the type locality, ten males and ten females had two flagellar segments beyond the fusion segment, and five males and seven females had three. In individuals from other localities, also, the number most often seen is two in addition to the fusion segment. Rarely, there is only one (Fig. 152). Variation in the number of rows of femoral setae, in the ventral tooth of the male dististyle, and certain other characters has already been noted. The lobes of the ninth tergum of the male vary from low and broad to prominent and longer than wide. Seen from above, the space between the gonapophyses may be narrowly U-shaped or a little constricted near the bases of the apical hooks. A single male in a collection of 18 individuals from an ice cave in Union Co., Oregon, has this space strongly constricted caudally (Fig. 158); the gonapophyses are atypical in other respects as well (Fig. 159), with relatively short, thick apical hooks. Compression by the basistyles during preservation may distort the gonapophyses by partial rotation to the sides or constriction of the space between them. The outline of the gonapophyses (in this and all other species) can also be made to vary by compression on a microscope slide, but this kind of distortion should not in interpreted as variation. In the genital furca of the female the deflected apices of the arms vary in the degree of sclerotization and may not be as dark as shown in the illustration. There is considerable variation also in the relative sizes—particularly the lengths—of the three teeth of the ninth sternum (cf. Figs. 161, 162).

Relationships.—The gonapophyses and antennae of the male and the combination of short eighth tergum and abbreviated antennae in the female show the close relationship of *Chionea alexandriana* with *nigra* and *jellisoni,* and suggest relationship with *excavata* and *lyrata* and a somewhat more distant relationship with *carolus* and *durbini.* This grouping of species (the *alexandriana* group) is reinforced by several other similarities, such as the structure of the ninth sternum in the female and the internal reproductive systems of both sexes. Within the group, *alexandriana* most closely resembles *C. nigra* n. sp., from which it differs most conspicuously in color. These two species may also be differentiated by the more prominent ventral process on the apical hook of the male gonapophysis and by the tridentate ninth sternum in the female of *alexandriana.* These is a difference—though not always apparent—in the shape of the fusion segment of the antenna, longer in *alexandriana,* short and broadly turbinate in *nigra.*

Geographic Distribution.—*Chionea alexandriana* has been found from the

mountains of western Alberta and southern British Columbia southward through Washington, Oregon, Idaho and western Montana, to the east of the Great Basin in the Wasatch Mountains of Utah and along the Sierra Nevada to western Nevada and east-central California. Only recently (1981) has this range been extended significantly northwestward, to the vicinity of Whitehorse, Yukon Territory, over 800 miles from the nearest known localities in southwestern Canada. (This locality is not included on the distribution map, Map 4). The species is generally montane, but occurs from near sea level to 3000 meters (9800 ft). It coexists with several other western species, both in its general range and in its particular habitats. It is the most widely distributed of the western group of species (Map 4).

Seasonal Distribution.—There are collection records from some part of the range for every ten-day period from 1 October through 20 April, with isolated collections in mid-September and mid-May. Concentrated local collections, such as those made by Garrett and Woods in British Columbia and Chapman in Montana, show a peak period of abundance of the adults in November and December and an almost equally large but more prolonged peak in February and March. There may be two generations per year. As for some other species, the largest number of separate collections is in late December and early January, probably as a result of academic holidays. The snow cover was sometimes fresh, other times older and firm, and varied from 2.5-3 ft in thickness. Temperatures recorded at times of collection ranged from 21-32°F. Although active at 22°F and slightly so at 21°F, *C. alexandriana* was in cold stupor at 19.5°F (Chapman, 1954: 362). Near Mara in the northern Okanagan Valley, British Columbia, Mr. H. J. Blurton, a trapper, observed *Chionea alexandriana* on the snow in open stands of spruce and balsam (but not in dense stands) near timberline, between 5000 and 6500 ft. He saw the insects occasionally during January through April and noted that they were active on the snow surface on stormy days in April but were not seen when the temperature was so high as to make the surface moist (Treherne, 1920). Data from many collectors are less complete and do not indicate whether the specimens were taken on snow or not; probably most were, as *Chionea* is ordinarily not otherwise likely to be seen. However, in the Lava Beds National Monument, Modoc Co., California, Mr. Joe Schuh collected a male of *alexandriana* from an abandoned nest of a pack rat (*Neotoma* sp.). Occurrence



Map 4. Range of *Chionea alexandriana*. Each spot represents one or more collections within a county (in the United States) or at a locality. A locality near Whitehorse, Yukon Territory, is not indicated on the map.

of *alexandriana* in an ice cave has been mentioned earlier.

Habitats.—The clearest picture of the ecological distribution of *Chionea alexandriana* comes from the studies of winter insects made in the Bitterroot Mountains in Missoula Co., Montana, by Dr. John A. Chapman (1954). He found the flies always on snow and invariably in forested areas, although sometimes several yards from the nearest tree. Chapman's collections were made at elevations from 3600-8000 ft, most of the flies being taken between 6000 and 7000 ft. The forest at these elevations is composed largely of lodgepole pine (*Pinus contorta*) and Douglas fir (*Pseudotsuga taxifolia*).

Collection Records.—ALBERTA: Banff National Park, Boulder Pass, 7490 ft, on 12 in of snow, 14 Oct. 1968, K. W. Richards (2♂, 1♀); Banff National Park, Castle Mountain (Mt. Eisenhower), on snow, 5400 ft, 0°F, sunny, 31 Jan. 1956 (2♂); Banff vicinity, 20 March 1930, Owen Bryant (1♂); same, but 15 April 1928 (1♂, 1♀); same, but on snow, 23 Oct. 1932 (1♂); same, but Cascade Mountain, 6000 ft, 26 Jan. 1928 (1♀); also, a few specimens without date or collector's name from vicinity of Banff; Jasper National Park, Twp. 43, Range 1, 6200 ft, Sta. 7, 2-4 Oct. 1964 (3♂, 4♀); same, but 7600 ft, Sta. 8 (2♀); Athabasca Glacier area, 13 Oct. 1970, G. G. E. Scudder (3♂, 1♀); W of Ya-Ha Tinda Ranch (about 20 mi N of Banff), 27 Jan. 1960 (5♂, 6♀, including 1 mating pair). BRITISH COLUMBIA: Cranbrook (49°31′N, 115°46′W), elevation about 3000 ft, on snow, 1 Nov. (2♂, 1♀), 2 Nov. (1♂), 4 Nov. (3♀), 10 Nov. (1♂), 14 Nov. (1♀), 17 Nov. (4♂, 3♀), 21 Nov. (1♀), 23 Nov. (1♂), 3 Dec. (1♀), 13 Feb. (1♀), 22 Feb. (1♂, 3♀, types), 15 March (3♂), 16 March (1♂, 2♀), 12 April (4♂, 2♀), 19 April (4♀), all collected by C. B. D. Garrett, with no years recorded; Glacier National Park, 7 Dec. 1979 (1♂), 24 Dec. 1979 (5♂, 3♀), 13 Feb. 1977 (1♂, 1♀), 20 Feb. 1980 (1♂, 2♀), 24 Feb. 1979 (4♂, 3♀), 16 March 1980 (4♂, 5♀), all collected by John G. Woods; Goldstream River, 118°45′W, 52°45′N, 26 Dec. 1979 (11♂, 9♀), John G. Woods; Hunter's Range, E of Mara (50°41′N, 118°45′W), elevation 5000-6500 ft, on snow, Feb. 1927 (4♀), March 1920, H. J. Blurton (4♂, 2♀, including a mating pair); Kootenay Valley, March-April 1921 (1♀); Manning Prov. Park, near 0°C, snowing heavily, 5000-5700 ft, 10 Feb. 1979 (4♂, 3♀); same locality, near 0°C, on deep snow, 4000 ft, 11 Feb. 1978 (1♂); same, Cambie Creek, –1°C, about 4300 ft, 16 Mar. 1980 (3♂, 7♀); same –8°C, 17 Feb. 1980 (1♂); same but about 0°C, after sunset, 4500-5800 ft, 16 Feb. 1980 (5♂, 8♀); same but –5 to +5°C, in dappled shade or bright sun, on snow, 28 Feb. 1981 (6♂, 6♀); all collected by S. G. Cannings; Manning Park, in shade on snow, 4000 ft, 3°C, 1 Mar. 1981, L. Vasington (1♂); same but on snow at dusk, about 0°C, 4000 ft, 9 Feb. 1980, R. J. Cannings (1♂); Garibaldi Prov. Park, Diamond Head Trail, about 4000 ft, –1 to 3°C, overcast, 5 Apr. 1981, S. G. Cannings (1♀); Mount Revelstoke National Park, 28 Nov. 1976 (1♀), 12 Dec. 1979 (1♀), 25 Dec. 1979 (1♀), 28 Dec. 1976 (1♂, 1♀), 13 Jan. 1980 (2♂, 5♀), 1 Feb. 1977 (1♀), 3 Feb. 1980 (1♀), 9 Feb. 1980 (2♂, 3♀), 10 Feb. 1980 (8♂, 6♀), 23 Feb. 1978 (1♂, 1♀), all collected by John G. Woods; Salmon Arm (50° 39′N, 119°16′W), 2 Jan. 1926 ("1-2-1926") (2♂); Silver Star Prov. Park, Silver Star Mt., on snow in sunshine, noon, 12 Jan. 1981, A. Bryan (1♂, 1♀); same but snowing lightly, near –3°C, 1100-1300 hrs, 29 Jan. 1981, A. Bryan (1♂, 4♀); Vancouver, on snow, 21 Jan. 1933, H. B. Leech (1♀); Vancouver vicinity, Hollyburn Mt., 1300 ft, on snow, 1 Apr. 1978, P. Withler (1♂); same but 4000 ft, on snow, –3°C, 1 Mar. 1979, S. G. Cannings (1♀); Crown Mt., 3 Nov. 1935, J. Poole

(1 ♂, 1 ♀); Mt. Seymour (15 mi NE Vancouver), 1000 m, overcast, snowing, 18 March 1980, A. Grass (1 ♀); Wells Gray Provincial Park (about 50°30′N, 120°00′ W), along willow flats, Stillwater, 1 Jan. 1962, P. Joslin (1 ♀); same area, on snow, 27 Jan. 1981, T. Goward (2 ♀); Yoho National Park, fir-pine habitat, Lake O'Hara, 12 Feb. 1977, C. W. Aitchison (1 ♂, 1 ♀); Yoho Park, 6 Feb. 1977 (1 ♀), 25 Feb. 1980 (1 ♀), both John G. Woods; Apex Mountain, Similkameen Dist., 6500 ft, on snow, 22 Dec. 1977, R. A. Cannings (1 ♀); Vaseux Lake, Okanagan River, 1900-2500 ft, on snow, 0-3°C, 23 Dec. 1980, R. J. Cannings (2 ♂); Mineral King Mine, 4500 ft, Toby Creek, near Lake Windermere, snowing, –1 to 0°C, coniferous forest, 8 Feb. 1960, G. O. M. Stewart (4 ♂); Whistler Mountain, 5000 ft, 10 Oct. 1970, I. Britt (1 ♀); Paul Ridge, 5000 ft, shady N slope, 0-1°C, 11 Jan. 1981, S. G. Cannings (1 ♀). CALIFORNIA: Alpine Co., Carson Pass, off Calif. Hwy. 88, 8600 ft, collected dead on snow 3-4 ft deep, 15 Dec. 1974, D. Durbin (1 ♂); Modoc Co., Lava Beds National Monument, Crystal Cave, in nest of dead pack rat, 9 Feb. 1962, J. Schuh and E. Hansen (1 ♂); Mono Co., Carnegie Inst. Exper. Sta., 9800 ft, on snow, 28 Oct. 1973, D. Durbin (1 ♂); Nevada Co., Sagehen Creek at Univ. Calif. Field Station, 16 March 1972, R. A. Haick (1 ♂); Plumas Co., near Caribou, 24 Jan. 1922, H. S. Barber (1 ♀). IDAHO: Benewah Co., Crystal Creek, on snow, 22 Dec. 1968, M. M. Furniss (2 ♂, 3 ♀); Boise Co., 0.25 mi E of Idaho City, on snow in pine forest, 7 Dec. 1974, G. A. Shook (1 ♀); Boundary Co., Round Prairie, 2-3 mi W of Addie on U.S. Hwy. 95, Hall Mt., walking on snow on old logging trail in mixed coniferous forest, in light rain, about 35°F, 11 Nov. 1973, A. Greene (1 ♂); Clearwater Co., East Fork of Potlatch River, 5.5 mi E of Bovill, on snow, 11 Dec. 1978, R. C. Biggam, T. F. Hansen and P. C. Schroeder (3 ♂, 1 ♀); Idaho Co., Clearwater National Forest, Mud Creek Jct., 25 Nov. 1978, R. C. Biggam and M. A. Maurer (1 ♂); Warm Springs Creek, about 20 mi SW of Lolo Pass, on U.S. Hwy. 12, 28 Dec. 1975, A. Greene (4 ♂, 2 ♀); Latah Co., 4 mi NE of Harvard, Lost Creek, on snow, 6 Dec. 1975, R. C. Biggam (1 ♀); 3 mi S of Helmer, Little Boulder Camp, 4 Dec. 1971, W. J. Turner (1 ♂, 2 ♀); 6-7 mi NW of Troy, along Big Meadow Creek, overcast, still, 20°F, 14 Dec. 1975, A. Greene (1 ♂); Big Meadows Rec. Area, 4.5 mi NNW of Troy, 9 Dec. 1973, M. C. Hunter (3 ♂); 4 mi E of Emida Summit, Alt. Hwy. 95, 11 Feb. 1978, D. M. Kirkbride (1 ♂, 1 ♀); Shoshone Co., Clarkia, on snow, 14 Dec. 1960, W. F. Barr (1 ♂); Gold Hill, on St. Joe Divide, S of Wallace, on snow, 6000 ft, 23 March 1957, D. Fellin (1 ♂). MONTANA: Glacier National Park, near foot of Lake McDonald, walking on snow, near 22°F, 31 Dec. 1966 (1 ♀); Lake Co., Lion Creek, Swan Valley, 4 March 1972, R. A. Haick (1 ♀); Lincoln Co., Leigh Lake, 20 mi S of Libby, 5200-5400 ft, on fresh snow on rocky ground with moss, bear grass and sparse shrubs, 17 Sept. 1976, L. Wright (1 ♂, 2 ♀); Mineral Co., St. Regis, on snow, 28 Dec. 1957, H. R. Dodge (3 ♂, 2 ♀); Missoula Co., Lolo vicinity, Bitterroot Mountains, on snow, 6000-7500 ft, 14 Feb. 1953 (14 ♂, 12 ♀, including 2 mating pairs); same, but 3800 ft (1 ♂, 1 ♀); near Lolo, on fresh snow, about 6500 ft, 14 March 1953 (2 ♂, 1 ♀); same, but 6700 ft (1 ♂, 1 ♀); Lolo, on fresh snow, Nov. 1950 (1 ♂, 1 ♀); near Lolo, on fresh snow, about 6500 ft, 8 Apr 1953 (7 ♂, 6 ♀); same, but 7800 ft, 16 May 1953 (1 ♂, 1 ♀); Missoula vicinity, on snow, 6 Feb. 1953 (2 ♂); same, but about 3600 ft, 9 March 1952 (1 ♂); same, but about 32°F, 21 Dec. 1952 (3 ♂); all collected by J. A. Chapman; Missoula Co., on snow 26 Feb. 1957, H. R. Dodge (1 ♂, 1 ♀); Elk Creek, Lubrecht Forest, 4000 ft, 22 Jan. 1972,

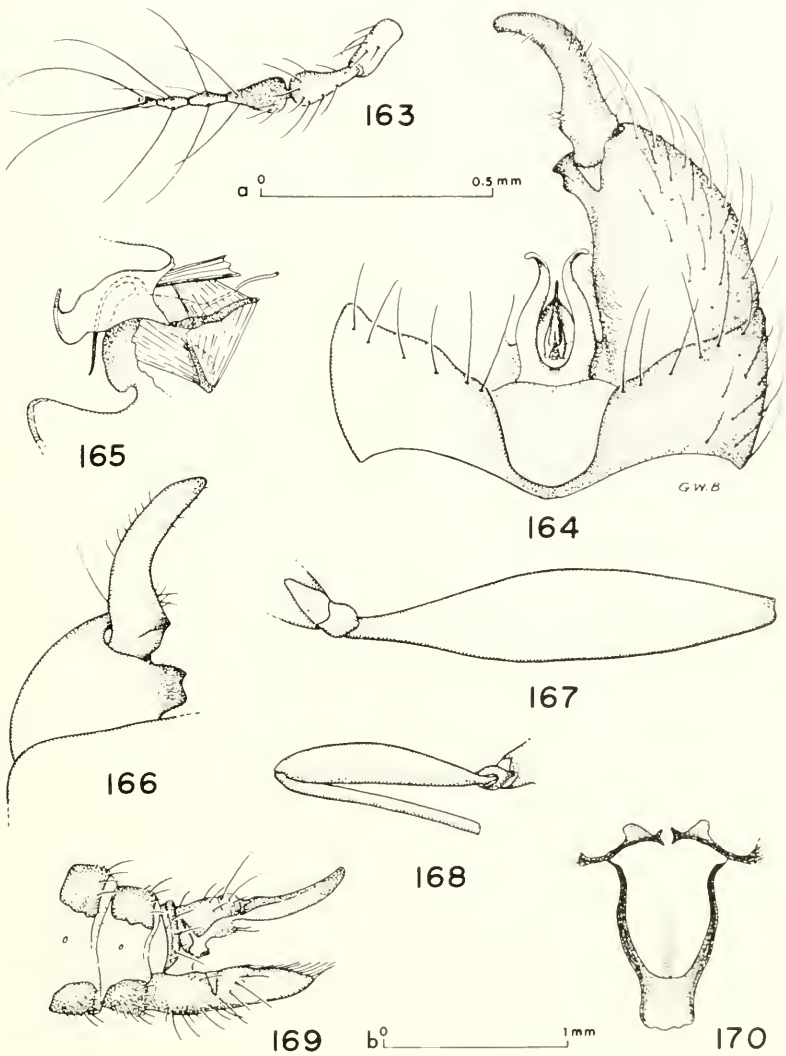
R. A. Haick, D. D. Jones and A. L. Costa (3 ♂, 7 ♀); Grant Creek, GC-3, 13 Feb. 1972, R. A. Haick (2 ♂, 1 ♀); Grant Creek, 13 Dec. 1971, R. A. Haick (1 ♂); Butler Creek, Snow Bowl, 15 Apr. 1972, R. A. Haick (1 ♀); Ravalli Co., Tin Cup Canyon, 3 mi W of Darby, on snow, near 4100 ft, 29 Nov. 1972 (2 ♂, 1 ♀); same, but 1 Dec. 1970 (2 ♂); same, but 13 Dec. 1973 (5 ♂, 2 ♀); same, but 16 Jan. 1972 (2 ♂, 1 ♀); all collected by W. L. Jellison; Lake Como, on snow, 31 Dec. 1969 (1 ♂); same, but 27 Nov. 1965 (1 ♀); Gird's Creek, vermiculite mines, on snow, 15 Oct. 1954 (1 ♂); all collected by W. L. Jellison; Tin Cup Canyon, 3 mi W of Darby, 4100 ft, on snow, 1 Jan. 1971, G. W. Byers (1 ♂, 1 ♀); West Fork Ranger Station, on snow, 28 Nov. 1962, W. L. Jellison (2 ♂, 1 ♀). NEVADA: Washoe Co., NE of Hunter Lake, Mt. Rose, 7200-8200 ft, 19 Jan. 1923, H. S. Barber (4 ♂). OREGON: Benton Co., Mary's Peak, Woods Creek Road, 7 March 1976, G. L. Peters (1 ♀); Clackamas Co., Mt. Hood, on snow, 32°F, 2 Jan. 1976, J. D. Lattin (1 ♀); Deschutes Co., Mt. Bachelor, on snow, 10°C, overcast, 26 Dec. 1980, L. Russell (2 ♀); same, 8000 ft, on snow, 3 Jan. 1969, K. Goeden (4 ♂, 8 ♀); 22 mi SW of Bend, near Todd Lake, 6300 ft, 21 March 1973, P. Lattin (1 ♀); Grant Co., Anthony Lakes Ski Area, on snow, 18 Feb. 1974, K. Goeden (7 ♂, 13 ♀); Hood River Co., 30 mi S of Hood River, 3 mi E of Bennett Pass, 20 Jan. 1974, P. Johnson (1 ♂, 3 ♀); Jefferson Co., Square Lake Trail, 1.5 mi E of Santiam Pass summit, on snow, 28 Dec. 1975, G. L. Peters (1 ♂); Klamath Co., Crater Lake National Park, on snow, park headquarters area, near 6500 ft, 15 Dec. 1957, D. H. Huntzinger (1 ♂); same, but 11 Feb. 1958, R. M. Brown (1 ♂); Lane Co., Pengra Pass, 22 mi SE of Oakridge, 5100 ft, 4 Jan. 1975, J. D. Lattin (1 ♂); Linn Co., McKenzie Pass, 5100 ft, 28 Dec. 1977, R. S. Zack (4 ♂, 4 ♀); 24 mi NW of Sisters, 4600 ft, 30 Dec. 1974, J. D. Lattin (3 ♂, 1 ♀); Lost Prairie, Willamette National Forest, on snow, 11 Jan. 1975, G. L. Peters (2 ♂, 1 ♀); 2 mi E of jct. of Oregon Hwys. 20 and 26, on snow, 18 Jan. 1975, D. C. Carlson (1 ♂, 1 ♀); Parish Lake Road, 6 mi S of Marion Forks, 3500 ft, 27 Jan. 1973, J. D. Lattin (1 ♂, 5 ♀); Lost Lake, on snow, 12 Jan. 1976, G. L. Peters (1 ♂); Potato Hill Road, near Lost Lake, on snow, 18 Jan. 1976 (1 ♀); 0.25 mi W of jct. Oregon Hwys 20 and 22, 4600 ft, on snow, 30 Dec. 1974, J. D. Lattin (1 ♂); 2.5 mi E of jct. Oregon Hwys. 20 and 22, 4500-5200 ft, near 0°C, 1 Feb. 1975, P. Johnson (2 ♀); Iron Mt., on snow, 31 Jan. 1981, L. Russell (5 ♂, 3 ♀); Pacific Coast Trail to N Santiam Pass, dead on snow, 20 Dec. 1980, L. Russell (2 ♂, 3 ♀); Sentinel Hills, Mt. Jefferson Wilderness, 4200-5500 ft, on snow, 22 Mar. 1981, L. Russell (1 ♂, 1 ♀); Marion Co., 1 mi W of Cheatcheek, about 3000 ft, 22 March 1975, R. J. Bury (1 ♂); Whitewater Creek, 14 mi NE Detroit, on snow, 3800 ft, 29 Mar. 1981, L. Russell (1 ♀); Polk Co., Laurel Mountain, 3000 ft, 21 Jan. 1978, L. Russell (2 ♂); Umatilla Co. (southeast), Bowman Meadows to Fly Creek, on snow, 16 Nov. 1962, J. Schuh (2 ♂); Union Co., from ice caves 10 mi S of Union, no date, R. Zack et al. (1 ♂, 17 ♀); Wallowa Co., Wallowa-Whitman National Forest, Eagle Cap Wilderness, 6000-7000 ft, weather clear, 24 Nov. 1972, A. Greene (2 ♂); same, but Lostine River, about 6000 ft, 27 Dec. 1974, no collector (1 ♀); same, but 3 Jan. 1975 (2 ♂); Wasco Co., 15 mi SE of Government Camp, Frog Lake Butte, 31 Dec. 1975, P. J. Johnson (4 ♂, 5 ♀). UTAH: Wasatch Co., Cascade Springs, Little Deer Creek, on snow, 29 Jan. 1966, E. C. Devenport (2 ♀). WASHINGTON: Chelan Co., near Wenatchee, No. 2 Cyn., 16 Dec. 1973, M. C. Hunter (1 ♀); Kittitas Co., near Lost Lake, S of Snoqualmie Pass, 3200 ft, on snow, about 1 per mile along logging road, 26 Nov. 1971,

J. S. Edwards (1 ♂, 2 ♀); Snoqualmie Pass, 1 Jan. 1976 (2 ♂); Spokane Co., Mt. Spokane State Park, 5000 ft, 9 Nov. 1975, A. Greene (5 ♂, 6 ♀); Yakima Co., 15 mi E of Chinook Pass, on snow about 2.5 ft deep, 17 Dec. 1977, P. J. Johnson (3 ♂, 6 ♀); near Yakima, 5000-6000 ft, on snow, April 1963 (1 ♂). YUKON TERRITORY: Evelyn Creek, near Whitehorse, on snow, 7 Jan. 1981, W. G. Johnston (2 ♂), same but 21 Feb. 1981 (2 ♀).

Chionea carolus Byers

Chionea carolus Byers, 1979: 719-722.

Diagnosis.—A small, dark brown *Chionea* of the northern and central Sierra



Figs. 163-170, *Chionea carolus*. 163, left antenna of male, lateral aspect. 164, gonapophyses, penis, vesica and its apodemes, right lateral aspect. 165, ninth abdominal tergum, left basistyle and left dististyle (tenth segment pushed inward to show gonapophyses), dorsal aspect. 166, left basistyle and dististyle, ventral aspect. 167, left hind femur, male, dorsolateral aspect. 168, right front femur and tibia, female, anterior aspect. 169, terminal abdominal segments, female, left lateral aspect. 170, ninth sternum and genital furca, female, ventral aspect. Scales: a—163-166, 170; b—167-169.

Nevada; antennae with four or five flagellomeres; male gonapophyses compressed, bowed outward near mid-length, convergent before acute apices, more than half length of basistyles; female cerci short, about 1.1 times length of hypovalves; ninth sternum formed of two subapically widened, apically bifurcate bands converging but not or barely in contact medially.

Description.—General appearance: Sclerites dark brown to brown, head blackish brown; membranous areas pale grayish brown; genital segment of male blackish brown; cerci of female amber brown. Femora in both sexes conspicuously thickened except slender near trochanteral attachments; hairs of legs relatively long. Length of male about 3-5 mm; female about 3.5-5 mm.

Head: Antennae (Fig. 163) comprising cylindrical scape, distally enlarged pedicel, long-conical fusion segment and three or four additional flagellomeres, the apical one very short. Setae of vertex stout but few and scattered. Eyes with about 70-90 ommatidia.

Thorax: Halteres pale grayish brown, conspicuously paler than dark brown thoracic dorsum. Femora slender and light brown to yellowish brown near attachments to trochanters, thickened and darker brown in both sexes through most of their lengths, especially noticeable in hind legs of male (Fig. 167) and fore legs of female (Fig. 168); seven or eight longitudinal rows of setae on femora, as well as a few scattered setae not in rows. Setae of tibiae nearly three times as long as tibial diameter, giving legs an unusually hairy appearance. Tarsi only about as dark as tibiae and femora.

Abdomen of male: Terga 1-8 with sparse, thick hairs along posterior margins, otherwise generally bare. Ninth tergum short, its posterodorsal emargination deep, U-shaped, extending nearly to base of tergum; no distinct lobes beside emargination but four to six long setae along margin at each side. Gonapophyses (Figs. 164, 165) proportionately large, more than half to nearly two-thirds length of basistyles, compressed, divergent near base but convergent just before slender, upturned, outwardly curved apices; penis curved downward at base, without other prominent curves, apex unmodified (Fig. 165); median, membranous pouch below gonapophyses with acute posteromedian margin. Basistyles only moderately thickened; posteromesal lobe darkly sclerotized, smooth (not pilose), with acute upper point and rounded lower one. Dististyles a little narrowed and most strongly curved near mid-length, with subacute but inconspicuous mesal tooth at base; ventral tooth not present. Ninth sternum with dense brush of dark yellowish brown setae near posterior median edge. Tenth (anal) segment membranous, small, protruding only to about mid-length of gonapophyses, of nearly uniform width throughout.

Abdomen of female: Terga 1-8 only sparsely hairy except for thick hairs along posterior margins; sterna more hairy and with scattered darkly pigmented spots. Eighth tergum darkly sclerotized throughout, short, slender, with slight dorsolateral thickening at each side (Fig. 169); lateral tips attenuate. Hypovalves of eighth sternum pale with darkened borders in apical two-thirds, brown basally; dorsal margin curved slightly ventrad toward acute apex, ventral margin smoothly upcurved, with a thin, translucent blade-like edge below marginal dark band. Genital furca (Fig. 170) lyre-shaped, narrowly joined to ninth sternum; latter in form of two convergent, strap-like extensions of lowermost corners of ninth tergum, each abruptly expanded before its shallowly bifurcate tip. Cerci short, approximately 1.1-1.2 times length of hypovalves measured from notch to tip, both dorsal and ventral margins evenly upcurved in lateral aspect; color dark amber brown.

Types.—Holotype, male, 1 mi S of

Hobart Mills, on snow, 5800 ft (1770 m), Nevada Co., California, 20 Dec. 1971, N. D. Penny. Allotype and 1 ♂, 1 ♀ paratypes, same data as holotype. Additional paratypes: California, Placer Co., 3 mi N of Tahoe Vista, on snow, 7000 ft (2154 m), 20 Dec. 1971, N. D. Penny. Entire type series preserved in alcohol, in Snow Entomological Museum, Univ. of Kansas.

Variation.—Overall length of males varies from 2.6 and 2.9 mm in two extremely contracted specimens (i.e., with abdomens strongly "telescoped") to 4.9 mm in a robust individual. Most males, however, are in the range of 3-4.5 mm. Females seen measure 3.1-5.1 mm, with nearly a normal distribution of lengths. As noted in the description, the terminal flagellomere is short. Two individuals (1 ♂, 1 ♀) from Mariposa Co., California, have four unusually short flagellomeres beyond the fusion segment. Another male from the same locality has four flagellomeres (including fusion segment) on one side, five on the other. Although *carolus* is generally a hairy-looking *Chionea,* this is due largely to the setae of the legs; and individuals with shorter, less dense hairs than usual are not rare. Considerably less variation in robustness is found in males of *C. carolus* than in most species; that is, the smaller males are not characterized by slender femora and relatively slender basistyles. There exists some variation in the proportionate length of the ninth tergum, which is shorter than in most species. The degree of development and sclerotization of the mesal tooth of the dististyle differs considerably among males; and size variation in the gonapophyses has been noted in the description.

Relationships.—Although in general appearance *C. carolus* does not very closely resemble other members of the *alexandriana* group, I have placed it among them mainly on the basis of the male gonapophyses. Antennal structure supports this placement; so also does the short (narrowly transverse) eighth abdominal tergum of the female. All characters considered, *carolus* is probably most like *C. lyrata,* geographically its nearest neighbor, with which it shares part of its range. It may be readily differentiated from *lyrata* (and from other species of the *alexandriana* group in the Sierra Nevada) by its small size, overall hairiness and dark color, by the expanded femora with slender bases, by the shape of the male ninth tergum (deep emargination and lack of projections) and gonapophyses, and by the absence of the ventral tooth of the dististyle.

Geographic Distribution.—A species largely of middle elevations in the northern and central Sierra Nevada, *C. carolus* has to date been collected in Alpine, Mariposa, Nevada, Placer and Tuolumne coun-

Map 5. Range of *Chionea carolus.* Each spot represents one or more collections within a county.

ties in California and Washoe Co. in Nevada (Map 5). This is roughly from just north of Lake Tahoe to Yosemite National Park. In his detailed study of winter insects in Yosemite National Park, David Durbin found fairly consistent altitudinal separation of *carolus* from the higher montane *C. durbini* and other, less common members of the *alexandriana* group. Elevations of collection sites of *C. carolus* range from 5800-8600 ft (1770-2646 m).

Seasonal Distribution.—Most specimens were found in the period 8-25 December, yet one male was collected on 4 November and another on 2 February. Probably there is a single, prolonged emergence of the adults in late autumn and early winter.

Habitats.—The habitats of *carolus* are chiefly in the lower lodgepole pine zone or upper ponderosa pine-sugar pine zone of the Sierra Nevada. Durbin (1975: 8) described the habitat at Crane Flat, Yosemite National Park, as follows: "The dominant trees are *Abies magnifica* (red fir), *Pinus lambertiana* (sugar pine), *A. concolor* (white fir) and *P. murrayana* (= *P. contorta,* lodgepole pine); other prominent parts of the biota include *Libocedrus decurrens* (incense cedar), *Arctostaphylos* sp. (manzanita), *Ceanothus* sp. (mountain lilac), *Prunus* sp. and *Phyllodoce breweri* (mountain heather)." (Common names in parentheses added by me.)

Collection Records.—CALIFORNIA: Alpine Co., Carson Pass, 8600 ft (2646 m), on fresh snow 3-4 ft deep, overcast, light snowfall, 12:30-1:30 P.M., 14 Dec. 1974, D. Durbin (1 ♂, 1 ♀); Mariposa Co., Crane Flat Meadows, Yosemite National Park, 6200 ft (near 1900 m), from log in snow, 25 Dec. 1972 (1 ♂); same, but on snow, 2 Feb. 1973 (1 ♂); same, but 8 Dec. 1973 (2 ♂, 3 ♀); same, but during snowfall, 21 Dec. 1973 (1 ♀); same, but on 8-10 in of powdery snow, 23 Dec. 1973 (3 ♂, 7 ♀); all collected by David Durbin; Nevada Co., 1 mi S of Hobart Mills, on snow, 5800 ft (1770 m), 20 Dec. 1971, N. D. Penny (2 ♂, 2 ♀, including types); Placer Co., 3 mi N of Tahoe Vista, on snow, 7000 ft (2154 m), 20 Dec. 1971, N. D. Penny (2 ♂, 1 ♀, paratypes); Tuolumne Co., Crane Flat Meadows (area is partly in Mariposa Co.), Yosemite National Park, 6190 ft, 4 Nov. 1972, D. Durbin (1 ♂). NEVADA: Washoe Co., 3 mi E of Tahoe Vista, on snow, 20 Dec. 1971, N. D. Penny (1 ♂, 2 ♀).

Chionea durbini, NEW SPECIES

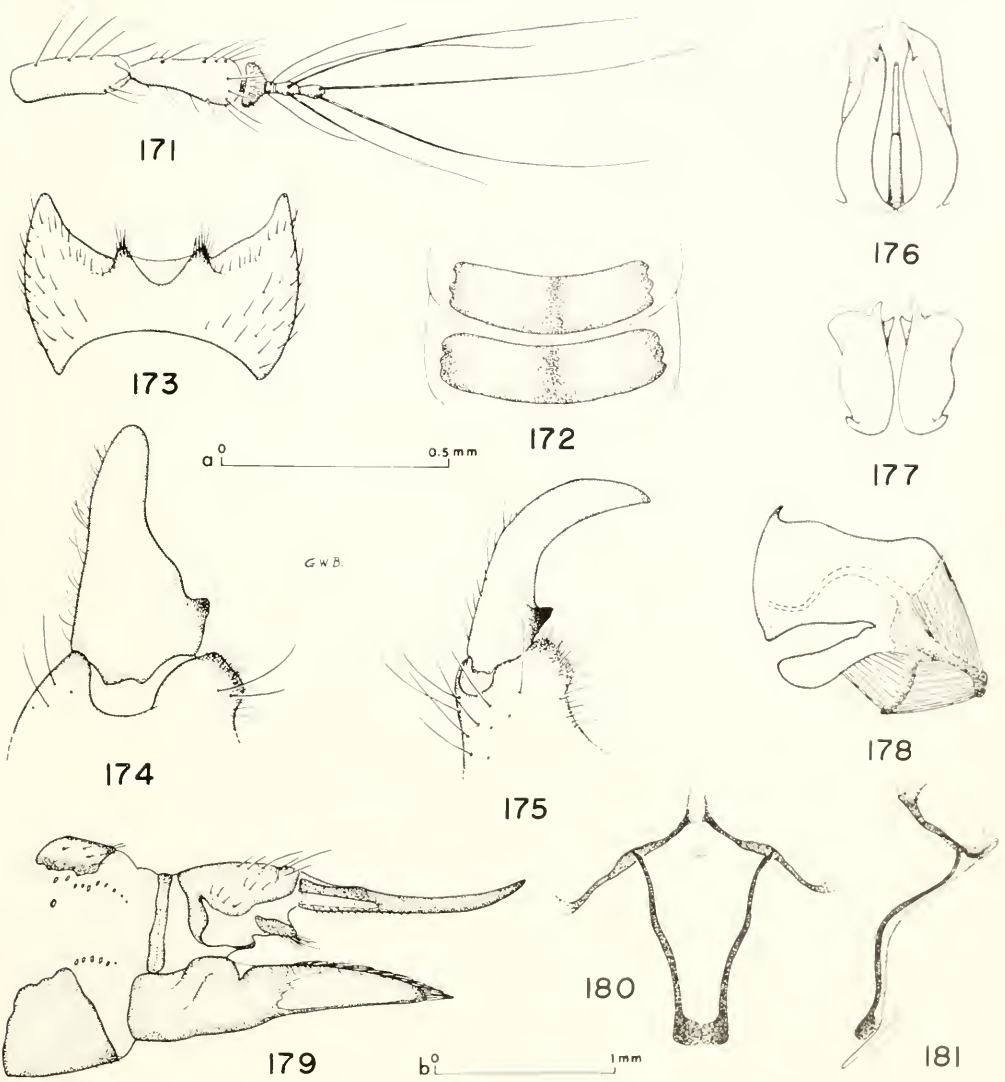
Diagnosis.—A brownish species of the central, high Sierra Nevada of California, with two or three flagellomeres; legs long and slender, tarsi contrastingly darker; male gonapophyses compressed but curved to present a widened dorsal aspect, truncate at apex and bearing a small posterodorsal tooth; cerci slender, extending well beyond hypovalves, upturned slightly in apical half.

Description (based on 17 ♂, 17 ♀, preserved in alcohol).—General appearance: Overall color of sclerites dark yellowish brown to brown, membranous surfaces dull pale brown; genital segment of male dark brown in most specimens; ovipositor of female amber brown; legs conspicuously long, tarsi much darker than tibiae. Length of male normally contracted, about 4.7-7.7 mm; length of hind leg 8.3-13.2 mm; female, 5.9-9.6 mm, hind leg 7.8-10.2 mm.

Head: Antennae (Fig. 171) comprising subcylindrical scape about three times as long as its diameter, pedicel not quite as long as scape, broadly conical or turbinate fusion segment, and usually two additional flagellomeres (if three, most proximal one very short as in Fig. 171). Setae on vertex and occiput long, slender, brown. Compound eyes with 110-120 ommatidia each, more in males than in females.

Thorax: Halteres pale brown, contrasting noticeably with thoracic dorsum in most individuals. Hairs of mesonotum, pronotum and coxae numerous, long, slen-

der, brown (not dark), longer on males than on females. Legs yellowish brown; hind femora of males only moderately incrassate, especially a little before midlength, those of females not noticeably enlarged. Femoral setae in seven longitudinal rows in females; setae much longer and with attenuate tips in males, in four rows on dorsal side of femur but very numerous and not in distinct rows on lower side. Basitarsi yellowish brown proximally, darkening to brown in apical half; other tarsomeres dark, blackish brown, in conspicuous contrast to leg color.



Figs. 171-181, *Chionea durbini*. 171, right antenna of large male, lateral aspect. 172, two abdominal terga (anterior at top), to show color pattern. 173, ninth abdominal tergum, male, dorsal aspect. 174, left dististyle and apex of basistyle, robust male (holotype), posterior (ventral) aspect. 175, left dististyle of more slender male, posteromesal aspect. 176, gonapophyses and penis, dorsal aspect. 177, gonapophyses, posterior aspect. 178, same as 176, right lateral aspect; structure below gonapophysis is dorsally concave portion of floor of genital chamber. 179, terminal abdominal segments, female allotype, left lateral aspect. 180, ninth sternum and genital furca, allotype, posteroventral aspect. 181, same, left lateral aspect. Scales: a—171, 174-178, 180-181; b—172-173, 179.

Abdomen of male: Terga 1-8 brown along mid-line and posterior and lateral margins, otherwise lighter brown with scattered small brown spots (Fig. 172); setae longest along posterior margins, others arising from some of scattered spots; corresponding sterna more uniformly brown. Ninth tergum (Fig. 173) with broadly U-shaped posteromedian emargination; at each side of emargination a lobe about as long as its basal width, bearing approximately ten setae. Gonapophyses (Figs. 176-178) actually compressed blades but having undulating surface sloping downward and inward from upper, outer margin, such that they appear both in dorsal and posterior aspect to have considerable thickness; on upper margin of each, near posterior end, a small point or tooth directed upward. Penis sinuate, with unmodified apex (Fig. 178, dashed line). Basistyles with broad, pilose posteromesal lobe; dististyles (Figs. 174, 175) with subacute mesal tooth at base, ventral tooth rarely present (absent in holotype). Tenth segment lightly sclerotized laterally, narrowed near mid-length to about half basal width.

Abdomen of female: Terga 1-7 with median brown stripe and brown lateral margins, otherwise pale brown with scattered brown spots; sparse setae arising from spots. Eighth tergum (Fig. 179) short (i.e., slender) throughout, with thin, darkened, sclerotized line near mid-length, from side to side. Cerci long, slender, evenly upcurved in apical half to acute tip, extending well beyond ends of hypovalves. Hypovalves nearly straight along lower edge, dorsal edge gradually curved downward toward narrowly rounded apex; blades mostly translucent, with amber-brown borders; dark yellowish hairs along outer half to two-thirds of dorsal margin. Genital furca lyre-shaped, its slender arms bowed both outward (Fig. 180) and dorsad (Fig. 181). Ninth sternum formed of convergent strap-like prolongations of lowermost corners of ninth tergum, each widened near attachment of furca and expanded slightly and abruptly just before lightly sclerotized median portion.

Types.—Holotype, male, near Carnegie Institute Experimental Station, Inyo National Forest, Mono Co., California, on 2-6 in of snow, 9800-10,300 ft, 14 October 1973, collected by David Durbin. This locality is in the high Sierra Nevada west of Lee Vining, at approximately 37°58′N, 119° 17′W. Allotype, female, and 2 ♂, 7 ♀ paratypes, same data as holotype. Paratopotypes: 13 ♂, 8 ♀, 28 October 1973, at 9800 ft (3015 m). One ♂ paratype, Yosemite National Park, Tuolumne Co., California, on snow in Dana Meadows, 9900 ft, 22 October 1972, David Durbin (locality is SW of Lee Vining, about 2 mi W of the Sierra crest, which is the county line). One ♀ paratype, California, Mariposa Co., Yosemite National Park, Crane Flat Campground, 6200 ft (1908 m), on snow, 9 December 1973, David Durbin. Holotype, allotype, and most paratypes in the California Academy of Sciences, San Francisco; 3 ♂, 2 ♀ paratypes in the Snow Entomological Museum, Univ. of Kansas, Lawrence. One additional female, badly damaged, is recognized as belonging to this species but is not made a paratype; it is from 10,350 ft (3185 m) on Mt. Dana, Tuolumne Co., California, 29 Oct. 1972, collected by David Durbin.

Relationships.—Chionea durbini generally resembles *C. alexandriana,* its size, color and short antennae contributing to the similarity. On the basis of the gonapophyses and dististyles of the male and the eighth abdominal tergum and ninth sternum of the female, however, I judge this species to be most closely related to *C. carolus,* geographically its nearest neighbor. It may be differentiated from the smaller *C. carolus* by antennal structure, shape of femora, and details of male and female genital segments. Specifically, the usual number of flagellomeres in *durbini*

is one fewer than in *carolus,* and the fusion segment is much shorter; the femora are much less incrassate in relation to their length; the gonapophyses of the male have an utterly different shape (cf. Figs. 176 and 164), and the cerci of the female of *durbini* are relatively much longer and more slender than in *carolus.*

This species is named for its collector, Mr. David Durbin, who has contributed greatly to our knowledge of *Chionea* and other winter insects of the Sierra Nevada through his collections and field observations.

Geographical Distribution.—This species is known only from the central Sierra Nevada of California, from about 1900-3200 m, in Mono, Tuolumne and Mariposa counties, which are contiguous (Map 6). Its range broadly overlaps that of *C. carolus,* although *durbini* generally occurs at higher elevations. It overlaps to a lesser extent the ranges of *excavata* and *lyrata* of the more northern Sierras and of the widespread *alexandriana.* Thus, *C. durbini* is the southernmost of the montane species of western North America.

Seasonal Distribution.—Specimens from high elevations (above 3000 m) were collected from mid to late October; those collected in December are from the lower elevations recorded. It seems probable that the weather at the type locality and others in the high Sierras is too severe in December for *Chionea* to be active.

Habitats.—This is a species of high elevations in the Sierra Nevada, where the subalpine forest of lodgepole pine (*Pinus contorta*) and white-bark pine (*P. albicaulis*) is patchy, giving way here and there to small willows (*Salix* spp.) and Sierra junipers (*Juniperus occidentalis*) just below tree-line. At the Carson Pass locality, mountain hemlock (*Tsuga mertensiana*) and red fir (*Abies magnifica*) were additional forest trees. While the trees are, of course, not the habitat of *Chionea,* they characterize the general habitat.

Chionea excavata, NEW SPECIES

Diagnosis.—A western montane species of brown to grayish brown color, with antennae of four (rarely three) flagellomeres; male gonapophyses hooked at tip, dististyles shallowly concave on outer (upper) curvature; female cerci evenly curved, not much longer than hypovalves; ninth sternum mostly lightly sclerotized, with narrowly triangular darker median structure.

Description (based on 3 ♂, 7 ♀, pinned, and 2 ♂, 1 ♀, originally pinned but removed to microscope slides).—General appearance: Head dark brown, thorax brown to grayish brown; abdominal sclerites brown, except ninth segment of male dark

MAP 6. Range of *Chionea durbini.* Each spot represents one or more collections within a county.

brown, cerci of female yellowish; pleural membranes light brown. Length of male about 4-6 mm, female about 6-7 mm, exclusive of antennae.

Head: Antennae (Fig. 182) comprising scape, pedicel and four flagellomeres (three in one specimen); fusion segment short-conical, its apical portion constricted at base in some specimens, resembling additional short segment. Eyes composed of about 80-100 ommatidia each.

Thorax: Halteres pale, contrasting with color of thoracic dorsum. Legs dark yellowish brown; seven (four dorsal, three ventral) longitudinal rows of setae on femora, sometimes an indication of fourth ventral row in male; tarsi brown.

Abdomen of male: Posterodorsal edge of ninth tergum (Fig. 183) with broadly V-shaped median emargination; at each side of emargination a low, blunt lobe bearing about six setae. Gonapophyses (Figs. 187, 188) broad at base, abruptly narrowed in distal half; apical portion hook-like, slender, curved upward, with blunt ventral heel-like process and acute tip; space between gonapophyses narrowly U-shaped; apex of penis unmodified. Basistyles thick, each with a bluntly rounded, pilose, posteromesal lobe (Fig. 184). Dististyles (Figs. 184-186) yellowish brown to reddish brown, thick at base, with blunt mesal tooth, somewhat flattened and shallowly excavated dorsally in apical half; excavated area largely pilose, also bearing scattered hairs as on remainder of outer (dorsal) surface of dististyle; ventral tooth small and blackened (holotype) to rudimentary. Tenth segment broad at base, narrowed near mid-length, darkly pigmented and pubescent laterally.

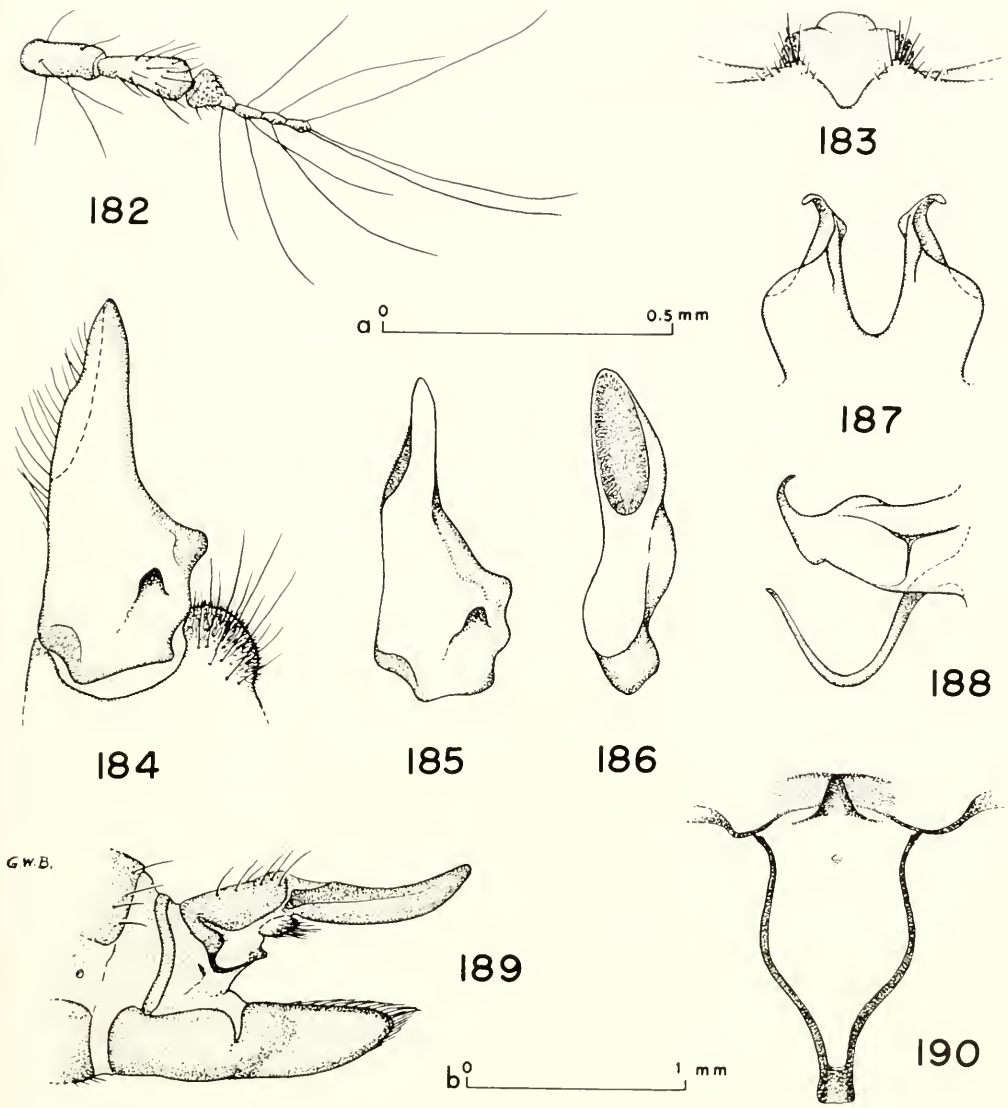
Abdomen of female: Eighth tergum short (i.e., slender) throughout. Hypovalves of eighth sternum deep, bluntly rounded at tip (Fig. 189), with lower margin more curved than dorsal margin. Arms of genital furca slender throughout; basal portion small, subrectangular, not much longer than wide. Ninth sternum with strongly sclerotized, narrowly subtriangular, projecting mid-ventral portion and a subquadrate, more lightly sclerotized and diffusely pigmented area above and to each side (Fig. 190). Cerci of medium length for genus, about 4.5-5 times as long as greatest width, evenly curved on both dorsal and ventral margins, about 1.2 times as long as hypovalves.

Types.—Holotype, male, 8 mi SW of Reno, Washoe Co., Nevada, elevation 7200-8200 ft, 19 January 1923, H. S. Barber collector. Allotype, female, same data as holotype. Paratypes: 1 ♂, 1 ♀, same data as holotype; 2 ♂, 4 ♀, northeast of Hunter Lake, Mount Rose, Washoe Co., Nevada, 7200-8200 ft, 19 January 1923; 2 ♀, near Caribou, Plumas Co., California, 27 December 1922; 1 ♂, near Caribou, Plumas Co., California, 24 January 1922 (1923?); all collected by H. S. Barber; 1 ♀, Washoe Co., Nevada, 3 mi E of Crystal Bay, 7300 ft, 20 Dec. 1971, N. D. Penny. Holotype, allotype, three male and six female paratypes in United States National Museum, Washington, D.C.; one male and one female paratypes (on slides) in Univ. of Michigan Museum of Zoology, Ann Arbor; one female paratype in Snow Entomological Museum, Univ. of Kansas, Lawrence.

Several female specimens from farther south in the Sierra Nevada apparently belong to this species. Since there are no associated males, however, these have not been made paratypes. All are in the collection of the California Academy of Sciences, San Francisco. The collection records are: CALIFORNIA: Alpine Co., Carson Pass, off California Hwy. 88, on snow, 8600 ft, 8:15 P.M., clear night, near 32°F, 14 Jan. 1975, D. Durbin (1 ♀); same place, but specimen found dead on snow, 1 P.M., clear day, 55°F, 15 Jan. 1975, D. Durbin (1 ♀); Mono Co., Inyo National Forest, Tioga Pass, Dana Meadows, 9900 ft, 26 Oct. 1968, R. P. Papp (2 ♀);

Inyo National Forest, Carnegie Inst. Exper. Sta., 28 Oct. 1973, D. Durbin (1 ♀); Tuolumne Co., Yosemite National Park, Mt. Dana, 11,000 ft, 29 Oct. 1972, D. Durbin (1 ♀); same general area, Dana Meadows, 10,000 ft, 15 April 1973, D. Durbin (1 ♀); same, but 16 April 1973 (1 ♀); same area, but Gaylor Peak, 11,000 ft, collected on snow, "6 VI 1973," D. Durbin (1 ♀) (Mr. Durbin states that the June date is correct but that the specimen may not have been alive when found).

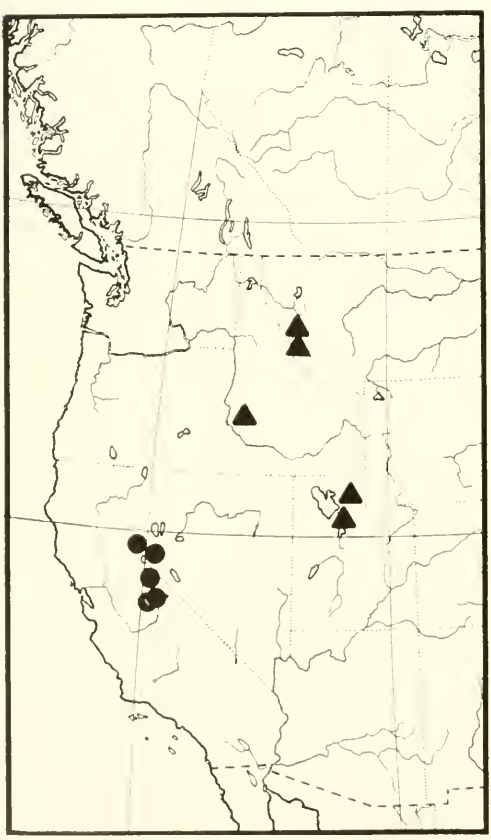
Variation.—Femoral setae in two of the males are very attenuate at the tip, many



FIGS. 182-190, *Chionea excavata*. 182, right antenna of male, lateral aspect. 183, posteromedian portion of ninth abdominal tergum and tenth segment, male holotype, dorsal aspect. 184, left dististyle, robust male (holotype), posterior (ventral) aspect; depression in outer, upper surface indicated by dashed line. 185, left dististyle of more slender male, posterolateral aspect (large hairs omitted). 186, same, dorsolateral aspect (ventral surface to right). 187, gonapophyses, dorsal aspect. 188, right gonapophysis and penis, right lateral aspect. 189, terminal abdominal segments, female paratype, left lateral aspect. 190, ninth sternum and genital furca, composite from two females, ventral aspect. Scales: a—182-188, 190; b—189.

tips slightly curled. The cerci of the female vary from 1.1-1.2 times as long as the hypovalves (measured from notch to tip). Variation in color and size have already been mentioned. The holotype is a larger male than the others and is somewhat more darkly colored but was selected because both antennae were intact. It has a dried nematode capsule around its neck.

Relationships.—*Chionea excavata* belongs to the *alexandriana* group and within this group seems, on the basis of the male genital structures, particularly the gonapophyses, most nearly akin to *alexandriana* and *nigra*. From both these species it differs in general coloration and number of flagellomeres. Males of *excavata* can be distinguished from those of all other species by the shallowly concave tips of the dististyles; the specific name (Latin *excavata* = hollowed out) refers to this unique characteristic. There is a close resemblance between females of *excavata* and those of *lyrata* n. sp. in the structure of the ninth sternum; however, *excavata* has relatively shorter cerci, a smaller number of flagellomeres, and a less distinct color pattern on the abdominal terga. In lateral aspect, the ventral margins of the hypovalves in *excavata* are more curved than the dorsal margins, while in *lyrata* both margins curve about equally toward the bluntly rounded apex.



MAP 7. Ranges of *Chionea excavata* (circles) and *C. jellisoni* (triangles). Each symbol represents one or more collections within a county.

Geographic Distribution.—This seems to be a species of the upper slopes (2215-3385 m) of the northern and central Sierra Nevada of California and westernmost Nevada (Map 7). So few specimens are known that the actual range is still unclear. This is the "species 1" recorded by Alexander (1967: 121), who through a misunderstanding reported the holotype from California (because I had sent him only the California records for the species).

Seasonal Distribution.—The very wide span of dates on which adults have been found, from late October to at least mid-April, suggests there may be two generations per year. The June collection record is unusual, yet not particularly to be doubted; apparently, suitable environmental conditions still prevailed at the time the specimen was collected.

Habitats.—Elevations in the Sierra Nevada at which *C. excavata* has been collected are mainly subalpine, characterized by mixed coniferous forests of lodgepole pine (*Pinus contorta*), white-bark pine (*P. albicaulis*), red fir (*Abies magnifica*), mountain hemlock (*Tsuga mertensiana*), and western or Sierra juniper (*Juniperus occidentalis*). The higher recorded sites are near local tree-line, where the white-bark pine and small junipers and willows are characteristic vegetation.

Chionea jellisoni, new species

Diagnosis.—A western montane species with antennae having three flagellomeres; male gonapophyses broad at base with slender tips turned upward and outward; female cerci curved evenly upward in apical half, very short (not quite as long as hypovalves) but wide in dorsal aspect, especially in basal half.

Description (based on 31 ♂, 50 ♀ preserved in alcohol, 7 ♂, 6 ♀ pinned).—General appearance: Head reddish brown to dark brown, antennae and mouthparts slightly paler; thorax dark yellowish brown to brown, a little paler dorsally between halteres; abdominal sclerites yellowish brown to light brown except ninth segment of male reddish brown to dark brown; pleural membranes pale, dull yellowish brown; cerci and apical half of hypovalves of female translucent yellowish. Length of male, exclusive of antennae, about 5.0-5.8 mm (holotype 5.8 mm); length of female about 6.5-7.4 mm (allotype 7.2 mm).

Head: Antennae (Fig. 191) comprising scape and pedicel of about equal length, and three flagellomeres; fusion segment broadly conical, slightly asymmetrical, wider than long, with apex somewhat prolonged, giving appearance of another short flagellomere; terminal hairs of flagellum a little longer than all antennal segments together. Setae on vertex pale yellowish brown to light brown. Compound eyes with about 140-150 ommatidia each.

Thorax: Color abruptly paler than that of head, evenly dark yellowish brown or brown, except for paler area on metathoracic dorsum. Halteres yellowish to brownish gray, slightly darker than abdominal pleura but not conspicuously paler than thoracic sclerites generally. Setae of mesonotum long, stout, not darkly sclerotized, in two longitudinal patches. Legs yellowish brown to light brown; tarsi only slightly darker than femora and tibiae. Femora with six or seven well defined rows of dark brown setae; tibial setae more slender than those of femora, slightly longer, also in readily discernible rows.

Abdomen of male: Terga and sterna evenly pigmented, without evident color pattern, except diffuse paler spots on terga of some individuals; tergal setae sparse, short, mostly along posterior margins of terga; sternal setae longer, more dense, especially at sides of sterna. Posterodorsal margin of ninth tergum (Fig. 192) with two prominent lobes separated by broadly V-shaped incision; approximately six setae of various lengths on or near apex of each lobe; setae laterad from lobes often longer than those on lobes. Gonapophyses (Figs. 193, 195, 196) broad in basal half, with slightly concave dorsal surface irregularly and shallowly emarginate at posterior edge; apical half becoming abruptly narrowed to elongate, slender, hook-like tip curving upward and outward; gonapophyses nearly in contact slightly beyond mid-length; apex of penis unmodified. Basistyles thick, their posteromesal lobes bluntly rounded or with two low prominences, with scant pilosity. Dististyles (Fig. 194) slightly paler than basistyles, evenly curved on outer surface, ridged along most of inner curvature except near mid-length, somewhat expanded slightly beyond mid-length. Mesal tooth of dististyle prominent, broadly subconical; ventral tooth also prominent, darkly sclerotized, usually with short, chisel-like apex (more nearly conical in holotype). Tenth segment only lightly sclerotized and pigmented laterally.

Abdomen of female: Terga and sterna uniformly pigmented; setae sparse, not much darker than sclerites, distributed about as in male. Eighth tergum a narrow, transverse strap, at widest (i.e., longest) only about one-third length of seventh tergum, without setae. Hypovalves deep, only slightly longer than basal portion of eighth sternum, with both upper and lower margins curving gently toward tips. Cerci

slightly shorter than hypovalves (ratio of 0.94 to 1.0), depressed, appearing of about uniform width throughout in lateral aspect (Fig. 199) but actually conspicuously widened in basal half (Fig. 197b), tapering toward acutely rounded apices. Ninth tergum without posterolateral setae; tenth tergum short, wide, with only slight indication of transverse sulcus near posterior margin (Fig. 197b). Basal portion of genital furca longer than wide, weakly sclerotized medially; arms of furca strongly bowed outward near mid-length, thickened near bases (Fig. 200). Median portion of ninth sternum more densely sclerotized marginally than centrally, slightly concave ventrally, with bluntly rounded median tooth and irregular, lightly pigmented areas in adjacent membrane (Figs. 200, 201).

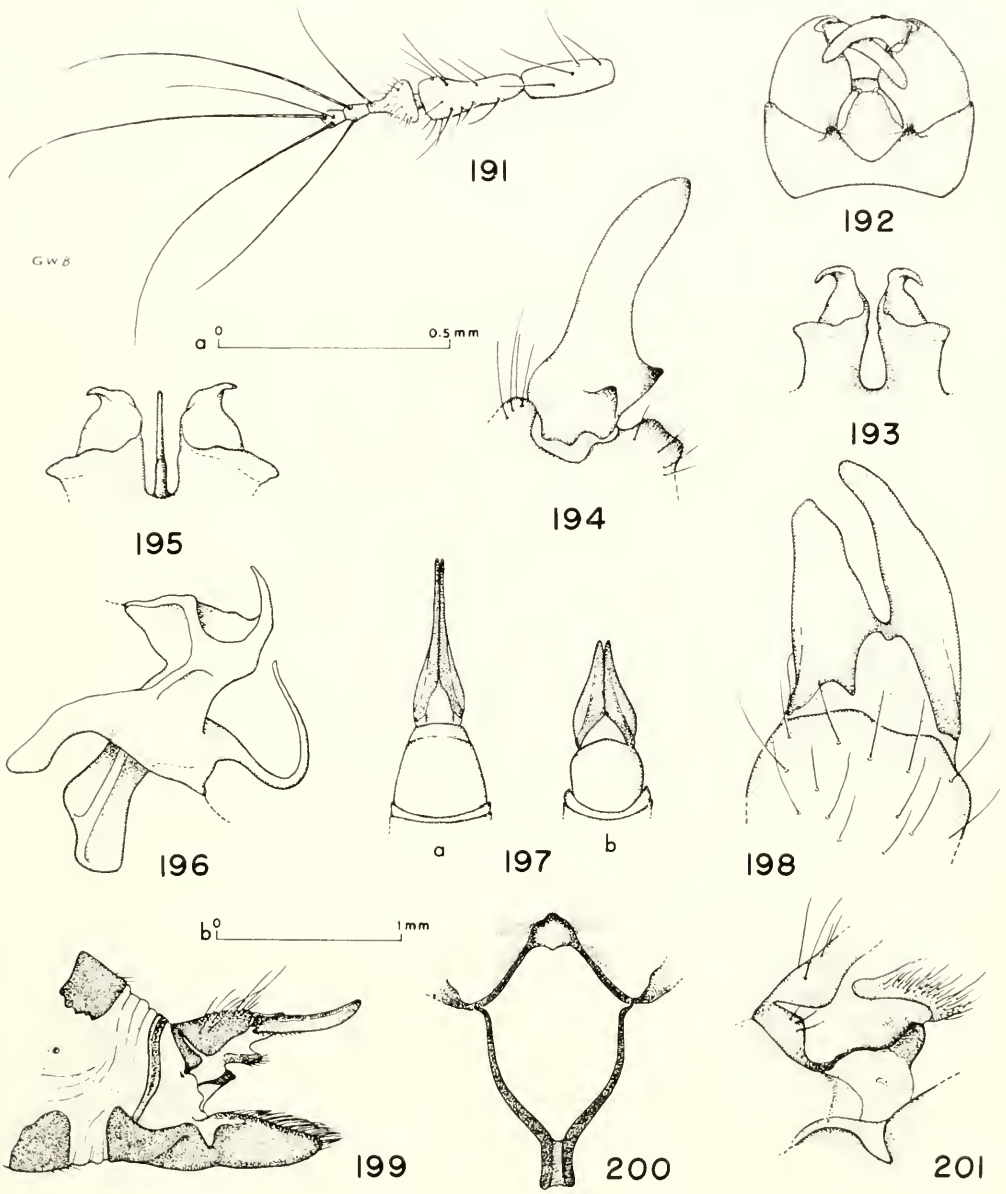
Types.—Holotype, male, Boulder Creek, Ravalli Co., Montana, on snow, 9 December 1956, collected by W. L. Jellison and R. Scott. Allotype, female, and 1 ♂, 4 ♀ paratypes, same data as for holotype. Additional paratypes: MONTANA: Ravalli Co., West Fork Boulder Creek, on snow, 29 Jan. 1966, W. L. Jellison (1 ♀); Lake Como Road, on snow, 27 Nov. 1965, W. L. Jellison (2 ♀); Tin Cup Canyon, 3 mi W of Darby, on snow, 1 Dec. 1970, W. L. Jellison and J. E. Keirans (2 ♂, 3 ♀, including a mating pair); Missoula Co., Elk Creek, Lubrecht Forest, 4000 ft, 22 Jan. 1972, R. A. Haick (14 ♂, 25 ♀, including one mating pair). IDAHO: Boise Co., 0.25-0.5 mi E of Idaho City, 21 Dec. 1974 (4 ♂); same, but on snow in pine forest, 7 Dec. 1974 (1 ♂); 11 mi N of Idaho City, on snow in pine forest, 7 Dec. 1974 (1 ♀); same locality, 30 Nov. 1974 (2 ♀); Idaho City, 14 Dec. 1974 (1 ♂); same locality, on snow, 16 Jan. 1976 (1 ♂, 2 ♀); T5N, R3E, Sect. 18, on snow at Bogus Basin, 27 Feb. 1977 (1 ♀); all collected by G. A. Shook. UTAH: Cache Co., Logan Canyon, Spring Hollow, near reservoir, on snow, 12 Nov. 1968, B. Geils (1 ♀); Salt Lake Co., Alta, on snow, 8585 ft, 12 Feb. 1975, K. J. Goeden (14 ♂, 13 ♀). Holotype, allotype and some paratypes in the Snow Entomological Museum, Univ. of Kansas; paratypes also in collections of W. L. Jellison (Hamilton, Montana), Univ. of Montana, and Utah State Univ. The type locality, Boulder Creek, is a tributary of the West Fork of the Bitterroot River, draining the north slope of Boulder Peak, in southwestern Ravalli Co.

Five females from Salt Lake Co., Utah, are identified as *C. jellisoni* but have not been made paratypes because of lack of associated males. These are: Neffs Canyon, 10 March 1966, R. W. Baumann (2 ♀); Albion Basin, Alta, 9 Feb. 1976, K. J. Goeden (3 ♀). Four of these females are much larger than others from the Wasatch Mountains and are darker, somewhat resembling females of *C. nigra*. At their type localities in Montana and Colorado, *jellisoni* and *nigra* are very different, but in Utah they seem to converge particularly with respect to color.

This species is named for Dr. William L. Jellison, renowned medical entomologist and collector of many of the type series. I am indebted to him not only for numerous specimens of *Chionea* and other winter insects but also for his good company on entomological walks in the forest in Montana and, many years ago, in Korea.

Variation.—One sees the usual variation in size in both sexes of *C. jellisoni* and in robustness in males. However, the degree of variation in number of antennal flagellomeres so common in other species is not found in this one. Virtually every specimen seen has two flagellomeres beyond the fusion segment; a short third one is rarely present.

Only once among the hundreds of specimens examined have I seen a developmental anomaly of the ovipositor. This is in a female of *jellisoni* from Boulder Creek, Ravalli Co., Montana (Fig. 198). The right cercus is short and thickened,



FIGS. 191-201, *Chionea jellisoni*. 191, left antenna, male holotype, lateral aspect. 192, ninth and tenth abdominal segments, holotype, dorsal aspect (most setae omitted). 193, gonapophyses, holotype, dorsal aspect. 194, left dististyle, holotype, posterior (ventral) aspect. 195, gonapophyses and penis, male from Utah, dorsal aspect. 196, gonapophyses, penis, vesica and its apodemes, male from Utah, left lateral aspect. 197a, b, comparison of tenth tergum and cerci, dorsal aspect, of females of *C. alexandriana* (a) and *C. jellisoni* (b), both from Missoula Co., Montana. 198, deformed cerci, female from Ravalli Co., Montana, dorsal aspect. 199, terminal abdominal segments, female allotype, left lateral aspect. 200, ninth sternum and genital furca, composite of two females, ventral aspect. 201, details of ninth and tenth segments, female, ventrolateral aspect. Scales: a—191, 193-196, 198, 200-201; b—192, 197, 199.

the left one of nearly normal length but apically curved toward the right side. Both cerci are badly deformed, as shown.

See under Types, above, concerning variations in some females from Utah that converge on the form of *C. nigra*.

Relationships.—Within the *alexandriana* species group, *C. jellisoni* is most similar in nearly every character to *alexandriana*, a species whose range it broadly overlaps. It is rarely the case that females of a species of *Chionea* can be more readily differentiated than males, but this is true of *jellisoni* and *alexandriana*. The most conspicuous difference is the cerci, which are much longer than the hypovalves and extend well beyond them in *alexandriana*, but which are slightly shorter than or about equal to the hypovalves in *jellisoni* (cf. Figs. 160, 199). In dorsal aspect, the difference is even more striking (Fig. 197a, b). There is also a difference in shape of the tenth abdominal tergum, in dorsal aspect (Fig. 197), and the transverse sulcus near the posterior end of this tergum is faintly developed in *jellisoni* but clearly impressed and usually somewhat pigmented in *alexandriana*. The median plate of the ninth sternum of *alexandriana* ordinarily is uniformly densely sclerotized, with three distinct posterior teeth, while in *jellisoni* it is more densely sclerotized along the margins and has only broadly rounded, indistinct posterior teeth as well as a small anterior point directed toward the aperture of the bursa copulatrix (Fig. 200).

Recognition of males is less easy. In general, the posterior margins of the broad, basal portion of the gonapophyses are more uneven and project farther laterad than in *alexandriana* (cf. Figs. 193, 195 and 156). The upturned apical hook is thicker in *jellisoni* and lacks the ventral, heel-like process seen in *alexandriana* (Figs. 196, 157). The ventral tooth of the dististyle is usually more strongly developed in *jellisoni*, in equally robust males of the two species. Actually, overall dorsal aspect is fairly reliable in this differentiation. The abdominal terga of *jellisoni* are unicolorous or nearly so, and the hairs on the terga are short, sparse, and occur mainly along the posterior tergal margins. In contrast, in *alexandriana* the terga are darker anteriorly, laterally and along the dorsal mid-line, and the hairs are longer than in males of *jellisoni* of equal size and are more evenly scattered over the tergum.

Earlier I have mentioned the problem of the relationship of *jellisoni* to the similar *C. nigra* in Utah, where the two are in contact.

Geographic Distribution.—As now known, the range of *C. jellisoni* extends from west-central Montana, especially the Bitterroot Range, southwestward through the Salmon River Mountains to the vicinity of Boise, Idaho, and southward through the Wasatch Range into northern Utah (Map 7). At the type locality the elevation is near 5000 ft (1538 m; elevations along Boulder Creek below Boulder Falls are from 4600-5400 ft). At the Lubrecht Forest site it is near 4000 ft (1231 m). At the southern end of the range, *C. jellisoni* was taken at 8585 ft (2642 m).

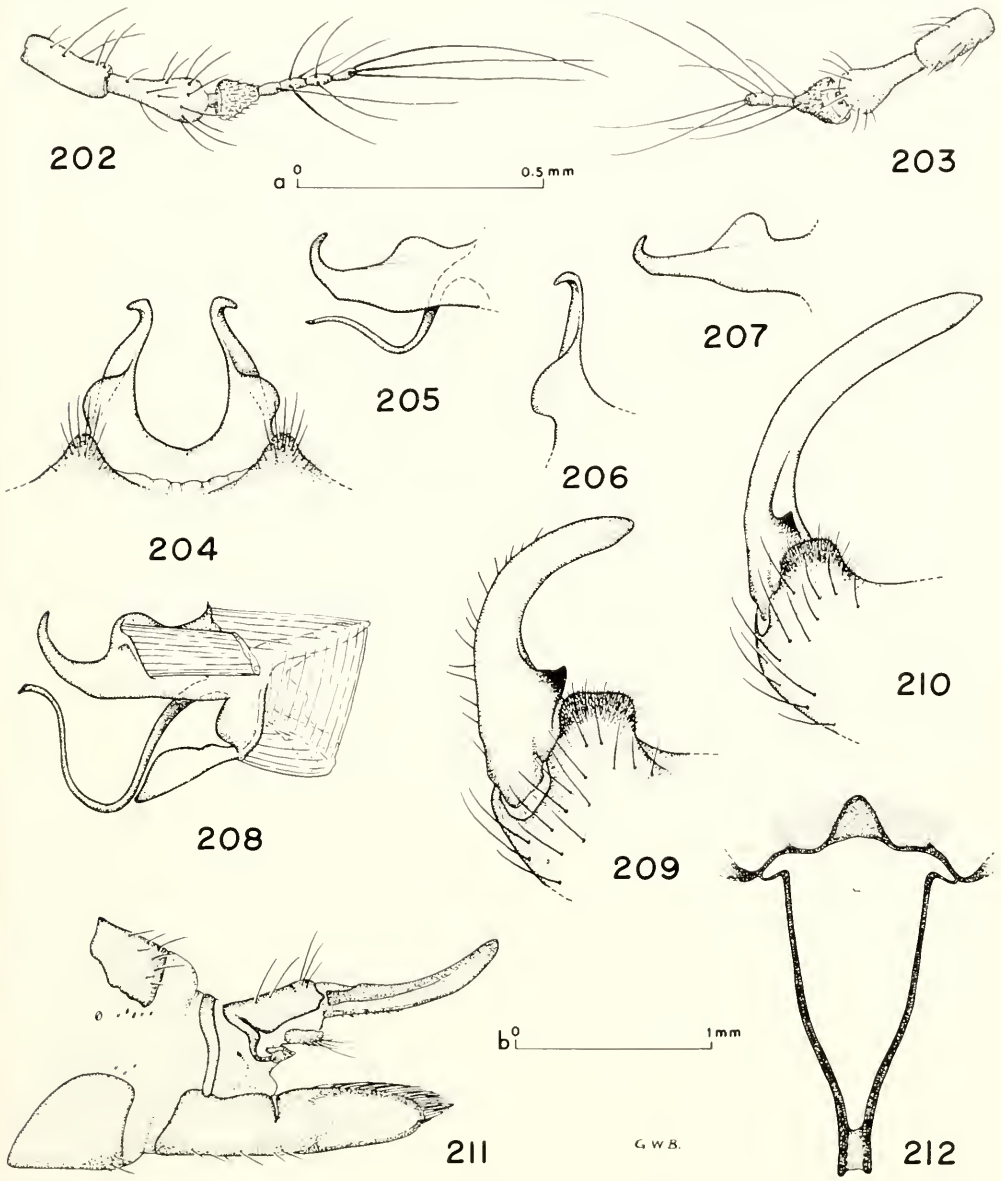
Seasonal Distribution.—Collection dates are spread rather evenly from late November to late February, but 70% of the individual specimens were taken in approximately the last month of this span. This probably represents a single but prolonged period of adult emergence.

Habitats.—At middle elevations, including the type locality, the forest macrohabitat of *C. jellisoni* is characterized by western yellow pine (ponderosa pine, *Pinus ponderosa*) and Douglas fir (*Pseudotsuga taxifolia*). At the higher elevations lodgepole pine (*P. contorta*) is the dominant conifer. In Ravalli and Missoula counties, Montana, the habitats are characterized further by approximately 30-degree slopes strewn with granitic boulders among the pines and firs. It was my impression that

these areas would be fairly dry near the surface in summer, while in winter they were covered with deep snow (2-3 ft and drifted deeper).

Chionea lyrata, NEW SPECIES

Diagnosis.—A western montane species, light brown to brown in color, with four or five antennal flagellomeres (rarely few-



FIGS. 202-212, *Chionea lyrata*. 202, left antenna of female, approximately dorsal aspect (slide-mounted). 203, left antenna of male from California, showing only two flagellomeres beyond fusion segment. 204, gonapophyses and posteromedian lobes of ninth tergum, male holotype, dorsal aspect. 205, gonapophyses and penis, holotype, right lateral aspect. 206, variant form of right gonapophysis, dorsal aspect. 207, same, right lateral aspect. 208, right gonapophysis, penis, vesica and its apodemes and muscles, and portion of floor of genital chamber, right lateral aspect. 209, left dististyle and apex of basistyle, male from Placer Co., California, ventromesal aspect (somewhat foreshortened). 210, same, mesal aspect. 211, terminal abdominal segments, female paratopotype, left lateral aspect. 212, ninth sternum and genital furca, reconstructed from slide-mounted specimen, ventral aspect. Scales: a—202-210, 212; b—211.

er), fusion segment subconical; male gonapophyses curved widely apart at base, somewhat convergent before apex, hooked upward at tip; female cerci upturned in distal half, clearly longer than hypovalves.

Description (based on 1 ♂, 3 ♀, pinned but apparently originally preserved in alcohol, one male, one female, removed from pins to microscope slides, and one male, one female in alcohol).—General appearance: Head dark brown, thorax brown; abdominal sclerites yellowish brown to brown, terga darker brown along mid-line and at lateral edges, ninth segment of male dark reddish brown, cerci of female yellowish; pleural membranes tan. Length of male about 4-7 mm, female about 4-8 mm, exclusive of antennae.

Head: Antennae (Fig. 202) comprising scape, pedicel and four or five flagellomeres; fusion segment subconical, its apical portion in some individuals constricted at base, resembling additional short segment. Eyes with about 140-160 ommatidia each.

Thorax: Halteres very pale, contrasting with color of thoracic dorsum. Legs yellowish brown; seven (four dorsal, three ventral) longitudinal rows of setae on femora; tarsi brown beyond mid-length of basitarsus.

Abdomen of male: Posterodorsal edge of ninth tergum (Fig. 204) with broadly U-shaped median emargination; at each side of emargination a small, blunt lobe bearing six or seven large setae and a few smaller ones. A patch of long, pale setae near posteromedian margin of ninth sternum. Gonapophyses (Figs. 204-208) somewhat widened at base, with rounded, dorsolateral flange, narrowing in distal half; apical portion hook-like, slender, curved upward, acute at tip, without ventral process; space between gonapophyses widest near mid-length, narrowed posteriorly; apex of penis unmodified. Basistyles thick, posteromesal lobe of each pilose, with two rounded protuberances in some individuals. Dististyles (Figs. 209, 210) long, slender, yellowish brown, palest apically, thick at base with blackened mesal tooth, narrowing abruptly, then evenly curved, more or less circular in cross-section, and smoothly tapering to tip; ventral tooth small and blackened, or rudimentary and not darkened, or absent. Tenth segment wide at base, narrowed near mid-length, a little pigmented laterally.

Abdomen of female: Eighth sternum short (i.e., slender) throughout. Hypovalves of eighth sternum deep, obtusely rounded at tip (Fig. 211). Arms of genital furca slender throughout; basal portion small, not much longer than wide. Ninth sternum with well-sclerotized, projecting, subtriangular, mid-ventral portion and a rounded, less densely sclerotized area above and to each side (Fig. 212). Cerci elongate, about 5.5 times as long as greatest width, curved upward in apical half, noticeably longer than hypovalves (ratio about 1.3 to 1).

Types.—Holotype, male, near Seneca, Plumas Co., California, 28 December 1922, H. S. Barber collector. Allotype, female, same data as holotype. Paratypes: 2 ♀, same data as holotype except one without date on label; 1 ♂, same locality as holotype but dated 23 Jan. 1923; 1 ♀, Sunnyside, near Seneca, Plumas Co., California, 25 Dec. 1922, all collected by H. S. Barber; 1 ♂, 1 ♀, 3 mi N of Tahoe Vista, Placer Co., California, on snow, 7000 ft, 20 Dec. 1971, N. D. Penny.

The type locality, Seneca, is on the North Fork of Feather River, 4.5 mi (7.2 km) south of the dam at the south end of Lake Almanor, in Plumas National Forest. Sunnyside is 2 mi southwest of Seneca. Holotype, allotype, and two female paratypes in the U.S. National Museum of Natural History, Washington, D.C.; male paratype and female paratopotype (on slides) in Univ. of Michigan Museum of Zoology, Ann Arbor; one male, one female paratypes in Snow Ento-

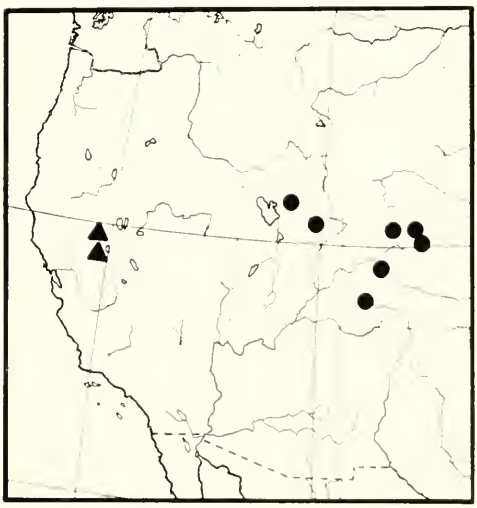
mological Museum, Univ. of Kansas, Lawrence.

Variation.—About half the specimens have three flagellomeres beyond the fusion segment, the others four (with one exception), so that neither count can, on the basis of the small number of specimens available, be said to be typical. In the holotype the number is three, in the allotype three in one antenna and four in the other. The male from Placer Co. has only two flagellomeres beyond the fusion segment (Fig. 203). Some of the specimens do not show the dorsal abdominal color pattern as clearly as do the holotype and allotype; and certain of the females have the abdominal pleural membranes fading from tan to whitish on the eighth and ninth segments. The holotype is a large male, 7.2 mm in length, its abdomen not telescoped, possibly as a result of the specimen's having been originally preserved in alcohol. Such preservation might also account for the somewhat bleached appearance, especially of the halteres and membranes, of the type and other specimens. It also might have accentuated the dorsal color pattern. In the holotype, the blackened lobe at the base of the dististyle is truncate at its tip, with a sharp, somewhat chisel-like edge (cf. Figs. 209, 210).

Relationships.—Although it differs a little from the other species of the *alexandriana* group in the structure of the gonapophyses, *Chionea lyrata* clearly can be placed with them on the basis of a combination of characters. It most closely resembles *C. excavata* in this species group. Comparison of Figures 204-205 and 187-188 will show that in spite of the evident differences in the gonapophyses the general form is the same. The specific name *lyrata* (from Greek *lyra*) is suggested by the lyriform arrangement of the gonapophyses. With respect to antennal structure, both the number of flagellomeres and the shape of the fusion segment, *lyrata*, is most like *excavata*. In the shapes of the genital furca and ninth sternum of the female, also, these two species are very similar. Their males may be distinguished easily by reference to the dististyles and gonapophyses, but the females may be recognized only by such less definite characters as the greater length and uneven curvature of the cerci and the more evident abdominal color pattern in *lyrata* (see discussion under *excavata*). The number of flagellomeres provides an indication of the species but is not altogether reliable. I do not know what variation in this (or any other) character a larger sample might show.

Geographic Distribution.—Only two localities are recorded for this species, both in the northern Sierra Nevada of California and only 80 mi (128 km) apart (Map 8). The known range extends approximately from Lake Tahoe northwestward to Lake Almanor. At Seneca the elevation is 3600 ft, but immediately adjacent slopes are 4400 ft (1354 m) and higher. Barber did not record how near the village, on Feather River, the Chioneas were taken.

This is the "species 2" recorded by Alexander (1967: 121). The range given by Alexander reflects my early confusion of



Map 8. Ranges of *Chionea lyrata* (triangles) and *C. nigra* (circles). Each symbol represents one or more collections within a county.

this species with certain individuals of *C. alexandriana*.

Seasonal Distribution.—This species has been found only during December and January, suggesting a single annual generation. Since the region in which *lyrata* was collected has been little explored for winter insects, it would be premature to exclude the possibility of a much longer period of adult emergence (as for other Sierran species) or even a second generation in March and April.

Habitats.—This seems to be a species of the Transition zone, or of middle elevations in the Sierra Nevada, where the dominant forest trees are ponderosa pine (western yellow pine, *Pinus ponderosa*), sugar pine (*P. lambertiana*) and white fir (*Abies concolor*). In the vicinity of Lake Tahoe, red fir (*A. magnifica*) and lodgepole pine (*P. contorta*) are also present. I have not seen the type locality but have several times traversed the more southern part of this range and found it generally dry and agreeably cool (for humans) in summer and deeply blanketed with snow in winter.

North of Tahoe Vista, *C. lyrata* was taken together with the smaller, darker *C. carolus*.

Chionea nigra, NEW SPECIES

Diagnosis.—A species of the central Rocky Mountains, black in overall color; antennae with two to four flagellomeres; male gonapophyses broad at base, slender and turned upward and laterad at tips; female cerci evenly curved, only slightly longer than hypovalves.

Description (based on 5 ♂, 7 ♀, pinned, 3 ♂, 4 ♀, in alcohol, and 2 ♂ 2 ♀, originally preserved in alcohol but removed to microscope slides).—General appearance: Macroscopically, overall color black. Microscopically, head black, thorax and abdomen dark brownish black, all with velvety texture; ninth segment of male black, cerci of female dark amber-brown. Length of male about 4.5-6 mm, pinned, to 8 mm on slide; female about 5-7 mm, pinned, to 8 mm on slide.

Head: Antennae (Fig. 213) consisting of scape, pedicel and usually three but rarely two or four flagellomeres; fusion segment short, broadly turbinate. Eyes with about 120-140 ommatidia each.

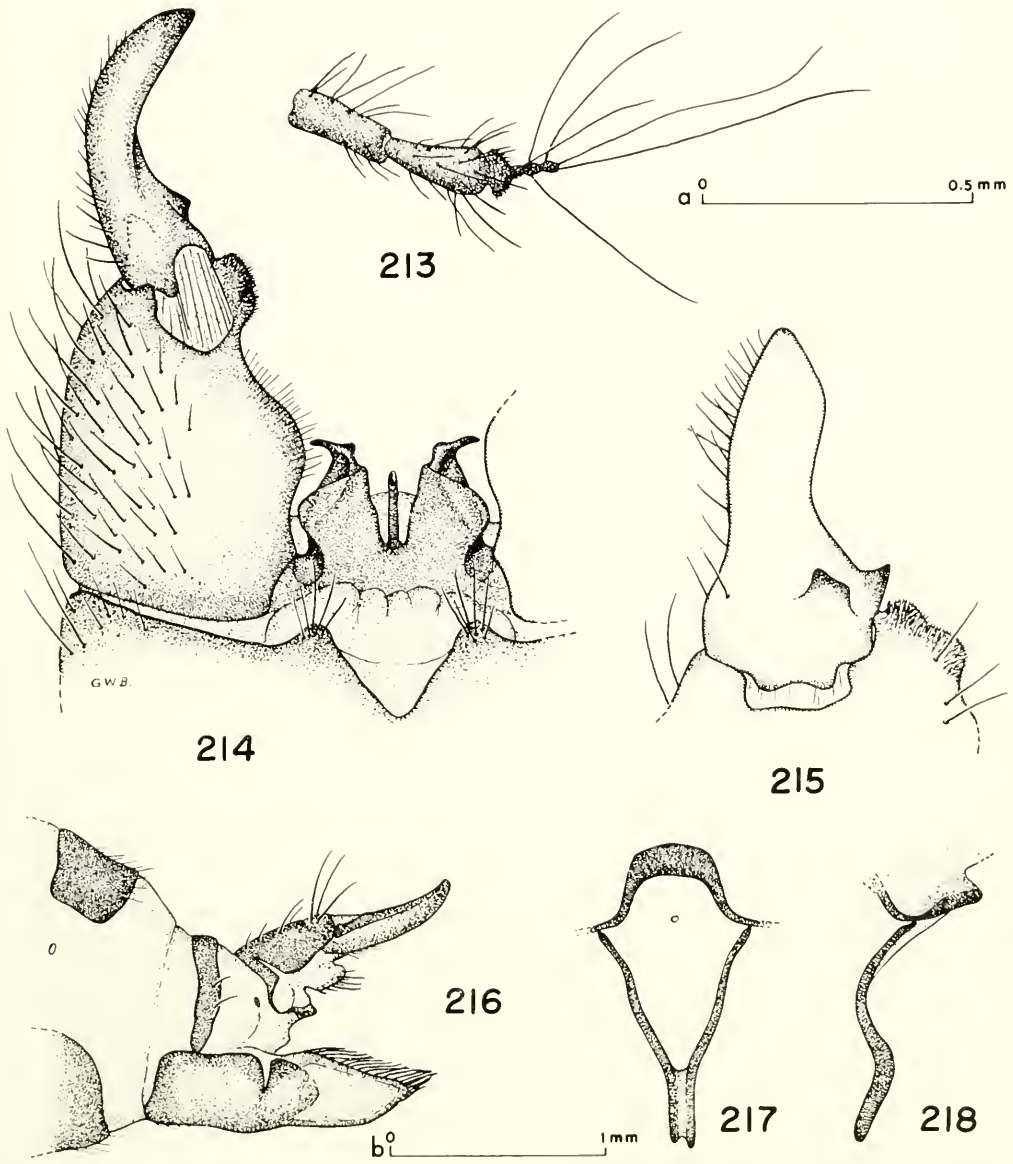
Thorax: Halteres dusky brown, not conspicuous by contrast with thoracic dorsum. Legs dark brownish black to blackish; seven or eight longitudinal rows of setae on femora, in female, to 11 (6 dorsal and 5 ventral), in larger males, the rows sometimes indistinct; tarsi black.

Abdomen of male: Posterodorsal edge of ninth tergum (Fig. 214) with broadly V-shaped median emargination; at each side of emargination a small, blunt lobe bearing about six setae. Gonapophyses (Fig. 214) broad at base, upper surface abruptly narrowed in distal one-third; apical portion hook-like, with a blunt ventral process, slender, curved upward and outward to acute tip; space between gonapophyses narrowly U-shaped; apex of penis unmodified. Basistyles thick, posteromesal lobe of each pilose, with two rounded protuberances (Fig. 215). Dististyles (Figs. 214, 215) dark reddish brown, thick, with blunt or sometimes truncate ventral tooth near base, narrowest and most strongly curved near mid-length, subacute at apex; mesal tooth sharply pointed, blackened, of variable size but present in all males examined. Tenth segment wide at base, narrowed a little beyond mid-length, lightly pigmented laterally.

Abdomen of female: Eighth tergum short (i.e., slender) throughout, less than one-third length of seventh tergum. Hypovalves of eighth sternum deep, ventral margin curved upward, dorsal margin nearly straight (Fig. 216). Arms of genital furca slender apically, slightly widened near base (Fig. 217); basal portion more than twice as long as wide. Ninth sternum

a strongly sclerotized, broad, transverse band narrowed abruptly and bent cephalad at each side (Fig. 217). Cerci about 4.5 times as long as greatest width, straight in basal one-third or more, then evenly upcurved both dorsally and ventrally, subequal in length to hypovalves or slightly longer.

Types.—Holotype, male, near the Continental Divide, Boulder Co., Colorado, elevation 9800 ft, 17 April 1952, William S. Osburn collector. Allotype, female,



FIGS. 213-218, *Chionea nigra*. 213, left antenna, male paratype, approximately dorsal aspect (slide-mounted). 214, details of ninth abdominal segment, male, dorsal aspect (left basistyle and dististyle and base of ninth segment omitted; tenth segment pushed inward to expose gonapophyses). 215, left dististyle and apex of basistyle, male from Utah, posteroventral aspect. 216, terminal abdominal segments, female, left lateral aspect. 217, ninth sternum and genital furca, ventral aspect. 218, same, left lateral aspect. Scales: a—213-215, 217-218; b—216.

same data as holotype except elevation 9500-11,000 ft and date 24 April 1952. Paratypes (essentially topotypic), all from near the Continental Divide, Boulder Co., Colorado: 1 ♂, 1 ♀, same data as allotype; 3 ♂, 1 ♀, 9600-9900 ft, 27 February 1953; 1 ♂, 9500 ft, 7 March 1953; 2 ♀, elevation not recorded, 20 March 1953; 1 ♂, 9800 ft, 31 March 1953; 1 ♂, 2 ♀, 10,000 ft, 8 April 1952; 1 ♀, 7 mi W of Nederland, 9500 ft, 10 April 1953; 1 ♀, 11,200 ft, 28 April 1953; 2 ♀, 11,300 ft, 26 October 1951; 1 ♂, 11,400 ft, 3 November 1951; 1 ♀, 1 ♀, 8 mi W of Ward, 11,400 ft, 10 November 1951; all collected by W. S. Osburn; 1 ♀, 1 mi N Nederland, 8500 ft, 27 Dec. 1970, G. W. Byers. Most of these specimens were taken on the high slopes above the Univ. of Colorado Mountain Research Station ("University of Colorado Camp" on some maps), about 14 mi W of Boulder. Additional paratypes: COLORADO, Larimer Co., 1 mi. NE of Cameron Pass, 9600 ft, 5 Feb. 1966, S. G. Wellso (1 ♂); Routt Co., Clark (on Elk River), on snow, 10 Jan. 1978, T. Marchell (1 ♂); San Miguel Co., Wilson Mountain, Telluride, on snow, 29 Dec. 1977, T. B. Smith (1 ♀). UTAH: Cache Co., Logan Canyon, Beaver Mountain, 28 Oct. 1963, R. Rust (1 ♂); Summit Co., Henrys Fork C. G. (campground?), Uinta Mountains, 20 Dec. 1975, R. Fort (1 ♂). Holotype, allotype, two male, three female paratypes, all pinned, and three male, three female paratypes, in alcohol, in the collection of the Univ. of Colorado Museum, Boulder, Colorado. Other paratypes are in the collections of the Univ. of Michigan, Univ. of Kansas, Colorado State Univ., Utah State Univ., Univ. of Wisconsin, and Cornell Univ. Two females from Rocky Mountain Biological Laboratory, Gunnison Co., Colorado, collected in winter 1980 by Sara Hiebert, have not been made paratypes.

Variation.—The usual number of flagellar segments is three, and where there is only one beyond the fusion segment it is clearly the result of fusion of two segments, there being the usual three terminal hairs as well as the dorsal and ventral hairs of the subapical segment, all on one rather elongate segment. Occasionally the fusion segment is narrowed apically, giving the appearance of an additional segment, and rarely this part actually becomes articulated with the fusion segment, resulting in four flagellar segments. The femoral setae vary in size, the smaller ones generally found in the dorsolateral and ventrolateral rows. The larger setae in males usually have attenuate, curved tips. Specimens preserved in alcohol appear a little lighter in color than those that are dried, the females especially having a dark brownish color, except for the head, which is black.

Relationships.—A member of the *alexandriana* group, *Chionea nigra* is most like *alexandriana* itself and may well be a geographically isolated derivative of that species. Males of *nigra* closely resemble those of *alexandriana* and *jellisoni* in most structural details that ordinarily are taxonomically useful, such as the shapes of the gonapophyses, dististyles, and ninth abdominal tergum, and the number of antennal segments. The ventral process on the hook of the gonapophysis is somewhat less prominent in *nigra,* but color, in this case, appears to be the easiest means of distinguishing the species. In females, also, the black color will differentiate *nigra* from all other species, and the short, evenly curved cerci and smoothly margined ninth sternum of *nigra* will serve further to distinguish this species from *alexandriana.* The specific name refers to species' overall black color.

Geographic Distribution.—*Chionea nigra* is so far known only from scattered localities at high elevations in Colorado and Utah (Map 8). This distribution does not present a very coherent pattern and clearly is fragmentary. The range of the species may be cut off to the north by the high, dry plains of southern Wyo-

ming, and the record from San Miguel Co., Colorado, is probably near the southern limit of the range. The specimens from Routt Co., Colorado, and Summit Co., Utah, supply only a tenuous connection to the Wasatch Range of central Utah, where *nigra* contacts the similar *C. jellisoni*.

Seasonal Distribution.—There are plainly two separate periods of occurrence of adults on the snow in the type locality, one in October and November, the other in late February, March and April. Since Osburn's study of the area was continuous and since he was watching for *Chionea* particularly during the entire 1952-1953 season, I believe that the interval between these peaks is actually a time when adults of *Chionea* are not present and that the peaks may represent two generations.

Habitats.—I am indebted to Mr. Osburn for several very useful observations on the environments in which this species occurs and for searching beyond the areas in which the insects were found, so that the pattern of ecological distribution was made clear. *Chionea nigra* was collected on 12 different dates in three years. In every instance the specimens were found on snow, although the extent of the snow cover varied from shallow and patchy in distribution to deep and completely covering the ground, the condition of the snow from freshly fallen and soft to several days old, with an icy crust at the surface. Collections made between 9500 and 11,200 ft elevation were in lodgepole pine (*Pinus contorta*) forest, except where as a result of fire these trees had been temporarily replaced by aspen, or, in one case, limber pine. Above 11,200 ft the forest is spruce (*Picea engelmanni*) and fir (*Abies lasiocarpa*) to timberline, which is near 11,500 ft in that vicinity. *Chionea nigra* was never found more than 100 ft from trees projecting above the snow level, while a species of *Boreus* often found in association with the tipulids was taken as high as 700 vertical feet above timberline (see Byers, 1955: 4). Four of the 12 collections, comprising nearly half the specimens, were made when the temperature was between 18°F (−7°C) and 29°F, the others at temperatures from 32-40°F (5°C). Most of the Chioneas were taken late in the day, a few at sunset or after nightfall, and some were found only after a prolonged search, suggesting the insects were coming out onto the snow surface as the light intensity was diminishing. Two were collected at 10:00 A.M. but on a day when the sky was completely overcast, and one was taken at 2:30 P.M. when there was a nearly complete cloud cover.

Literature Cited

Ainslie, C. N. 1906. The snow fly, *Chionea valga*. Can. Entomol. 38: 275-276.

Alexander, C. P. 1916. New or little-known crane-flies from the United States and Canada: Tipulidae, Ptychopteridae, Diptera. Part 3. Proc. Acad. Nat. Sci. Philadelphia 68: 486-549.

———. 1917. New nearctic crane-flies (Tipulidae, Diptera). Part III. Can. Entomol. 49: 199-211.

———. 1919. The crane-flies of New York. Part I. Distribution and taxonomy of the adult flies. Cornell Univ. Agr. Exp. Sta., Mem. 25: 765-993.

———. 1920. The crane-flies of New York. Part II. Biology and phylogeny. Cornell Univ. Agr. Exp. Sta., Mem. 38: 691-1133.

———. 1922. The biology of North American crane-flies (Tipulidae, Diptera). VI. The genus *Cladura* Osten Sacken. Pomona Coll. J. Entomol. Zool. 14: 1-6.

———. 1940. Undescribed species of crane-flies from the eastern United States and Canada (Dipt.: Tipulidae). Part VI. Entomol. News 51: 83-85, 99-103.

———. 1941. New nearctic crane-flies (Tipulidae, Diptera). Part XVI. Can. Entomol. 73: 206-213.

———. 1942. Family Tipulidae. *In* The Diptera or true flies of Connecticut. Conn. State Geol. Nat. Hist. Survey, Bull. 64: 196-509.

———. 1946. New nearctic crane-flies (Tipulidae, Diptera): Part XXVII. Can. Entomol. 78: 155-159.

———. 1949. Records and descriptions of North American crane-flies (Diptera). Part VIII. The Tipuloidea of Washington, I. Amer. Midl. Natur. 42: 257-333.

———. 1954. Records and descriptions of North American crane-flies (Diptera). Part IX. The Tipuloidea of Oregon, I. Amer. Midl. Natur. 51: 1-86.

———. 1956. Undescribed species of crane-flies from the eastern United States and Canada (Dipt.:

Tipulidae). Part XII. Entomol. News 67: 177-185.

———. 1965. Family Tipulidae, p. 16-90. *In* A. Stone et al. (eds.), A Catalog of the Diptera of America North of Mexico. USDA Handbook No. 276. Washington, D.C. 1696 pp.

———. 1967. The crane flies of California. Bull. California Insect Survey 8: 1-269.

ALEXANDER, C. P. and G. W. BYERS. 1981. Tipulidae, p. 153-190. *In* J. F. McAlpine et al. (eds.), Manual of Nearctic Diptera. Vol. 1. Agr. Canada Monogr. 27. 674 pp.

BEZZI, M. 1919 (1917). Rinvenimento di una *Chionea* (Dipt.). Bull. Soc. Entomol. Italiana 49: 12-49.

BIGOT, J. M. F. 1854. Essai d'une classification generale et synoptique de l'ordre des insectes Diptères. III. Ann. Soc. Entomol. France, ser. 3, 2: 447-482.

BITSCH, J. 1955. Le genre *Chionea* (Diptera, Tipulidae). Ecologie, systématique et morphologie. Trav. Lab. Zool. Stat. Aquicole Grimaldi, Fac. Sci. Dijon 11: 1-26.

BRAUER, F., J. EGGER and G. FRAUENFELD. 1854. Beobachtungen über die Entwicklungsgeschichte der *Chionea araneoides*. K.-k. Zoologische-Botanische Gesellschaft in Wien Verhandl. 4: 609-616.

BURGHELE-BĂLĂCESCO, A. 1969. Révision des genres *Chionea* et *Niphadobata* en Europe centrale et méridionale (Dipt. Tipulidae). Ann. Soc. Entomol. France, nouv. ser., 5: 983-1000.

BYERS, G. W. 1955. A new species of *Boreus* (Mecoptera: Boreidae) from Colorado. Occ. Papers Univ. Michigan Mus. Zool., No. 562: 1-4.

———. 1961*a*. Biology and classification of *Chionea* (Diptera: Tipulidae). Verhandlungen, XI Internationaler Kongress für Entomologie 1: 188-191.

———. 1961*b*. The crane fly genus *Dolichopeza* in North America. Univ. Kansas Sci. Bull. 42: 665-924.

———. 1963. Type specimens of North American Tipulidae (Diptera) described by Francis Walker. J. Kansas Entomol. Soc. 36: 146-161.

———. 1979. *Chionea carolus*, a new species of snow crane fly from California (Diptera: Tipulidae). J. Kansas Entomol. Soc. 52: 719-722.

CHAPMAN, J. A. 1954. Observations on snow insects in western Montana. Can. Entomol. 86: 357-363.

CHENG, T. C. 1973. General Parasitology. Academic Press, N.Y. 965 pp.

COULIANOS, C.-C. and A. G. JOHNELS. 1962. Note on the subnivean environment of small mammals. Arkiv. för Zoologi., ser. 2, 15: 363-370.

CRAMPTON, G. C. 1925. Evidences of relationship indicated by the thoracic sclerites of certain eriopterine tipuloid Diptera. Insecutor Inscitiae Menstruus 13: 197-213.

———. 1942. The external morphology of the Diptera. *In* The Diptera or true flies of Connecticut. Conn. State Geol. Nat. Hist. Survey Bull. 64: 10-165.

CURRAN, C. H. 1925. Three new Diptera from Labrador. Can. Entomol. 57: 24-26.

DALMAN, J. W. 1816. Försök till systematisk uppställning af Sveriges fjärilar. *Chionea araneoides*, ett nytt inländskt insect af tvåvingarnes ordning. K. Vetensk. Acad. Handl. (ser. 3) 37 (1816): 48-101, 102-105.

DOANE, R. W. 1900. New North American Tipulidae. J. New York Entomol. Soc. 8: 182-198.

DURBIN, D. V. 1975. The ecology of insects and other arthropods found on Sierran snow fields. M.A. Thesis. San Francisco State Univ., California.

EDWARDS, F. W. 1936 (1935). Pupae and living adults of *Chionea lutescens* Lundström from Denmark. Proc. Roy. Entomol. Soc. London 10: 89-91.

ENDERLEIN, G. 1936. Ordnung: Zweiflügler, Diptera. Die Tierwelt Mitteleuropas 6, Insekten, III Teil, Abt. 16. Quelle-Meyer, Leipzig. 259 pp.

GARRETT, C. B. D. 1922. New Tipulidae from British Columbia (Diptera). Proc. Entomol. Soc. Washington 24: 58-64.

GRAHAM, R. E. 1966. Crane-flies (Trichoceridae, Tipulidae) in California caves. Cave Notes 8: 41-48.

HACKMAN, W. 1961. Über die Dipterenfauna in den Gängen von Feldmäusen (*Microtus arvalis*). Verhandlungen, XI Internationaler Kongress für Entomologie 1: 215-217.

———. 1963*a*. Studies on the dipterous fauna in burrows of voles (*Microtus, Clethrionomys*) in Finland. Acta Zoologica Fennica 102: 1-64.

———. 1963*b*. On the dipterous fauna of rodent burrows in northern Lappland. Notulae Entomologicae 43: 121-131.

Hågvar, S. 1971. Field observations on the ecology of a snow insect, *Chionea araneoides* Dalm. (Dipt., Tipulidae). Norsk Entomologisk Tidskrift 18: 33-37.

HARRIS, T. W. 1835. Insects, p. 553-602. *In* E. Hitchcock (ed.), Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts, 2nd ed. Amherst, Mass. 702 pp.

———. 1841. A Report on the Insects of Massachusetts, Injurious to Vegetation. Cambridge, Mass. 459 pp.

———. 1852. A treatise on some of the insects of New England, which are injurious to vegetation. White, Boston. 513 pp.

———. 1862. A treatise on some of the insects injurious to vegetation, 3rd ed. Boston, Mass. 640 pp.

HAYWARD, J. S. 1965. Microclimate temperature and its adaptive significance in six geographic races of *Peromyscus*. Can. J. Zool. 43: 341-350.

JOHNSON, C. W. 1907. The snow-fly, *Chionea valga* Harris. Psyche 14: 41-43.

———. 1912. Dipterological notes. Psyche 19:102-104.

KRATOCHVIL, J. 1936. Renseignements sur les espèces du genre *Chionea* Dalm. de Tchécoslovaquie (Dipt., Tipulidae). Bull. Société Entomologique de France 41: 243-250.

LEONARD, M. D. 1928. A list of the insects of New York. Cornell Univ. Agr. Exper. Sta. Mem. 101: 1-1121.

LUGGER, O. 1897 (1896). The snow-fly, p. 230-231. *In* Insects injurious in 1896. Minnesota Agr. Exper. Sta., Ent. Ann. Rept. 2. 270 pp.

MAIL, G. A. 1930. Winter soil temperatures and their relation to subterranean insect survival. J. Agr. Res. 41: 571-592.

MARCHAND, W. 1917. Notes on the habits of the snow-fly (*Chionea*). Psyche 24: 142-153.

MATSUDA, R. 1970. Morphology and evolution of the insect thorax. Mem. Entomol. Soc. Canada No. 76: 1-431.

———. 1979. Abnormal metamorphosis and arthropod evolution, p. 137-256. *In* A. P. Gupta (ed.), Arthropod Phylogeny. Van Nostrand Reinhold Co. 762 pp.

NEEDHAM, J. G. 1908. Crane flies, p. 199-248. *In* Report of the Entomologic Field Station conducted at Old Forge, N.Y., in the summer of 1905. *In* E. P. Felt, 23rd Rept. State Entomol. 1907 (New York State), App. C.

OSBURN, W. S. 1958. Ecology of winter snow-free areas of the alpine tundra of Niwot Ridge, Boulder County, Colorado. Ph.D. Thesis, Univ. of Colorado.

OSTEN SACKEN, C. R. 1869. Monographs of the Diptera of North America. Part IV. Smithsonian Misc. Coll., No. 219. Washington, D.C. 345 pp.

———. 1878. Catalogue of the described Diptera of North America. 2nd ed. Smithsonian Misc. Publ. 16 (270): 1-276.

———. 1887. Studies on Tipulidae. Part II. Review of the published genera of the Tipulidae brevipalpi. Berliner Entomol. Zeitschrift 31: 163-242.

PETERSON, A. 1916. The head-capsule and mouthparts of Diptera. Illinois Biol. Monogr. 3: 1-112.

PRITCHARD, G. and P. SCHOLEFIELD. 1978. Observations on the food, feeding behavior, and associated sense organs of *Grylloblatta campodeiformis* (Grylloblattodea). Can. Entomol. 110: 205-212.

REES, B. E. and G. F. FERRIS. 1939. The morphology of *Tipula reesi* Alexander (Diptera: Tipulidae). Microentomology 4: 143-176.

RONDANI, C. 1841. Sopra una specie di insetto dittero. Memoria I. Nuovi Ann. delle Sci. Nat., Bologna 6: 284.

———. 1856. Dipterologiae Italicae Prodromus. Vol. I. A. Stoschi, Parma. 228 pp.

SÖMME, L. and E. ØSTBYE. 1969. Cold-hardiness in some winter active insects. Norsk Entomologisk Tidsskrift 16: 45-48.

SNODGRASS, R. E. 1935. Principles of Insect Morphology. McGraw-Hill, N.Y., 667 pp.

STONE, A., C. W. SABROSKY, W. W. WIRTH, R. F. FOOTE and J. R. COULSON (eds.). 1965. A catalog of the Diptera of America north of Mexico. U.S.D.A. Handbook No. 276. Washington, D.C. 1696 pp.

STRINATI, P. and V. ALLEN. 1967. Faune actuelle de deux grottes suisses de haute altitude. Rass. Speleol. Ital. (Como) 19: 84-87.

TORRE-BUENO, J. R. de la. 1920. The growth of insect eggs after oviposition. Bull. Brooklyn Entomol. Soc. 15: 24.

TREHERNE, R. C. 1920. A note on the wingless tipulid *Chionea valga* Harris. Can. Entomol. 52: 201-202.

WALKER, F. 1848. List of the specimens of dipterous insects in the collection of the British Museum. Part I. E. Newman, London. 229 pp.

WASHBURN, F. L. 1907. *Chionea valga* in Minnesota. Can. Entomol. 39: 103.

WILLISTON, S. W. 1908. Manual of North American Diptera. 3rd ed. J. T. Hathaway, New Haven, Conn. 405 pp.

WOJTUSIAK, H. 1950. The temperature preferendum of winter insects of the genus *Boreus* (Panorpatae) and *Chionea* (Diptera). Bull. Internat. Acad. Pol. Sci. Lettr. (Polska Akademia Umiejetnosci, Wydzial matematyczno-przyrodniczy), Ser. B-2, Zoologique, 11: 123-143.

ZETTERSTEDT, J. W. 1842. Diptera Scandinaviae. Vol. I. Officina Lundbergiana, Lund. 440 pp.

———. 1852. Diptera Scandinaviae. Vol. II. Officina Lundbergiana, Lund. 4091-4545 pp.

APPENDIX 1

Chionea wilsoni, NEW SPECIES

(see p. 142)

Diagnosis.—A generally yellowish, southern Appalachian species with long antennae having 10-11 flagellomeres; male gonapophyses inwardly and downwardly inclined, flattened blades with narrowly rounded apices; dististyles spatulate with mesal concavity in apical half; female cerci long, slender but slightly widened subapically; abdominal terga with distinct brownish markings.

Description (based on 6♂, 4♀, preserved in alcohol).—General appearance: Head yellowish brown to brown, thorax yellowish brown, palest dorsally; abdominal terga yellowish brown distinctly patterned with brownish lateral borders and median spot, sterna pale yellowish brown narrowly darkened with brown at sides; pleural membrane pale grayish yellow. Length of male, exclusive of antennae, about 3.1-5.2 mm (holotype 5.2 mm), female 4.0-5.8 mm (allotype 5.1 mm).

Head: Antennae (Fig. 219) with pedi-

cel longer than cylindrical scape; number of flagellomeres usually 11, the first (fusion segment) subconical, about 1.5 times as long as its basal diameter; antennal length, holotype, 1.72 mm. Clypeus and maxillary palps brown. Setae of vertex mostly long, dark, slightly curved. Eyes with about 90-110 ommatidia each.

Thorax: Thoracic dorsum pale grayish yellow to yellowish in central area, grading into brown laterally, darkest on anterior edge of pronotum and around anterior spiracles. Halteres grayish yellow to pale yellowish brown, not contrasting noticeably with color of nota. Mesonotal setae in two uneven longitudinal rows of 3-4 larger setae; a few smaller hairs. Legs yellowish to yellowish brown; femora with six rows of long, slender, dark setae; tibial setae about as long as those of femora; basitarsi yellowish brown grading into brown in apical one-fifth, other tarsomeres dark brown to nearly black.

Abdomen of male: Posterior median margin of ninth tergum (Figs. 221, 224) entire or shallowly indented medially in anterodorsal aspect, narrowly notched at mid-line in dorsal aspect, projecting dorsad and caudad, bearing numerous long, slender setae. Gonapophyses (Figs. 225, 226) flattened blades, steeply inclined, dorsal edges about three times as far apart as ventral edges, somewhat thickened at base, each roughly triangular, narrowing posteriorly to acutely rounded apex. Penis with angular deflection dorsad shortly before mid-length, bearing small, finger-like appendage at each side just beyond mid-length; apex unmodified. Posteromesal lobes of basistyles (Figs. 222, 223) scarcely evident, evenly rounded, bearing numerous hairs. Dististyles (Figs. 222, 223) dark yellowish brown, spatulate, with large mesal concavity in apical half, with broadly rounded apex and small, darkened subapical tooth on anterior margin; mesal tooth prominent, darkly sclerotized, slightly upcurved, with small concavity above its base on dorsal surface; ventral tooth a small, rounded protuberance, only slightly darkened. Tenth segment pale yellowish gray, not projecting far beyond ninth tergum, abruptly narrowed near mid-length. Most abdominal terga pale yellowish brown conspicuously patterned with brown median spot and lateral margins (Fig. 220); setae submarginal along posterior edge and sides.

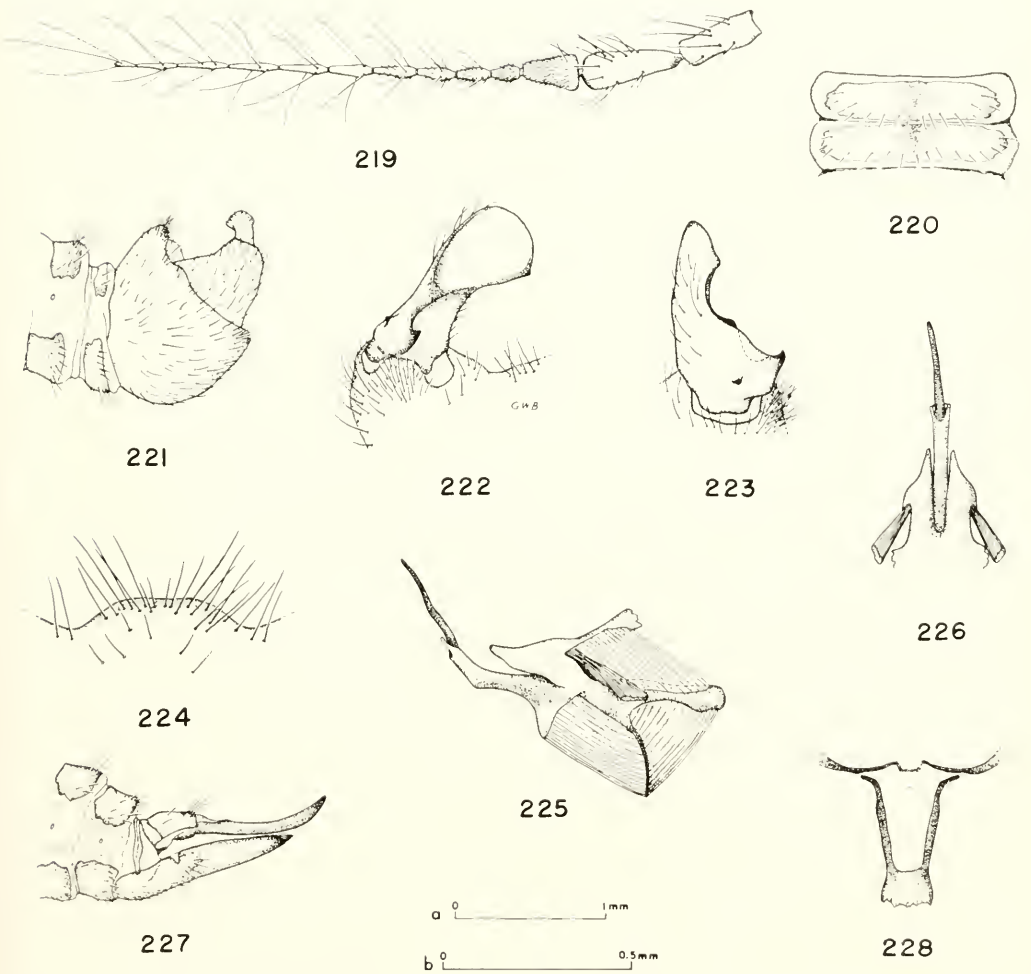
Abdomen of female: Eighth tergum short, or slender, throughout, slightly expanded at each side to about one-fourth length of seventh tergum, without setae, yellowish brown with transverse reddish brown, more densely sclerotized stripe connecting lateral apices (Fig. 227). Hypovalves of eighth sternum elongate, their ventral margins nearly straight, dorsal margins evenly downcurved to acutely rounded apex; margins amber-brown, central area pale yellowish brown, translucent. Arms of genital furca (Fig. 228) not conspicuously bowed, narrowed and curved abruptly outward in apical one-fifth of their length; basal portion wider than long, weakly sclerotized medially. Each side of ninth sternum slender, tapering toward midline to join moderately sclerotized, subtriangular median structure protruding ventrally. Cerci long, slender, slightly widened before acute apex, about nine times as long as their greatest width, approximately 1.3 times as long as hypovalves measured from notch to tip. Setae of terga 6 and 7 neither thicker nor darker than those of more anterior terga.

Types.—Holotype, male, Calhoun Co., Alabama (T14S, R9E, Sect. 17), 11 December 1980, elev. about 1200 ft, collected by Dr. Cole L. B. Benton. Allotype, female, topotypic, 5 Dec. 1980. Paratypes, all collected by Cole Benton and all from northeastern Alabama: 1 ♂, Calhoun Co., along road by Camp Cottaquilla, T14S, R9E, Sect. 32, about 900 ft, 31 Dec. 1980; 4 ♂,

same locality, 26 Jan. 1981; 1 ♀, topotypic except Sect. 18, about 1200 ft, 6 Dec. 1980; 1 ♀, Cherokee Co., Little River Canyon rim (west side), near stream by Powell Trail, 21 Dec. 1980; 1 ♀, Talladega Co., Talladega National Forest, Mump Creek at road between Ironaton and Clairmont Gap, 2 Jan. 1981.

Holotype and allotype in the Snow Entomological Museum, University of Kansas; paratypes returned to Dr. Benton, who plans to deposit some in the collection of the Ohio State University, Columbus.

At the suggestion of the collector, Dr. Benton, this striking new species is named in honor of Prof. Edward O. Wilson of Harvard University. This recognizes Prof. Wilson's great contributions in theoretical biology (sociobiology in particular) and in myrmecology, and that he was born and



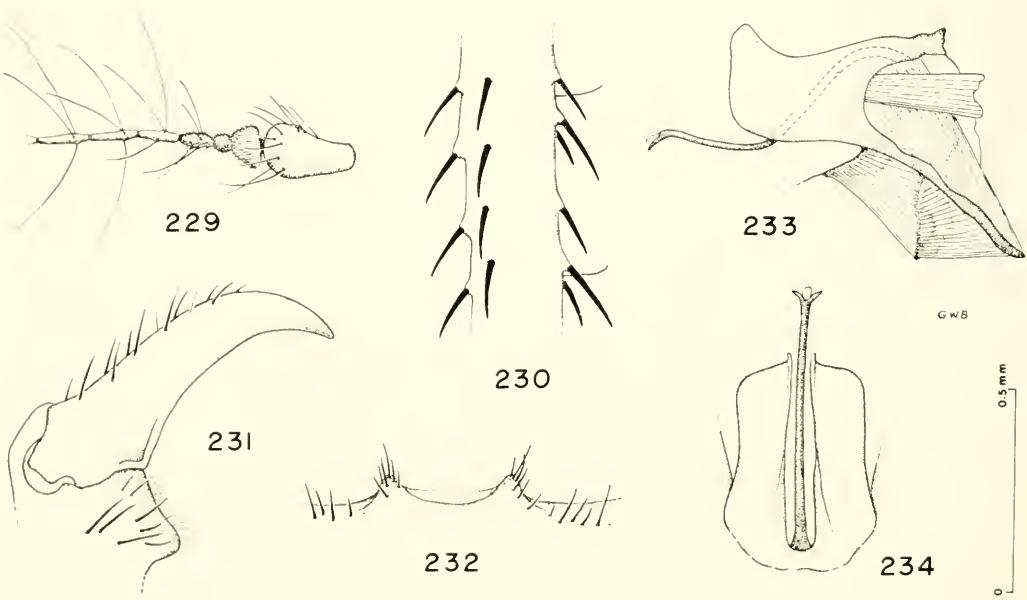
Figs. 219-228, *Chionea wilsoni*. 219, left antenna, male holotype, left lateral aspect. 220, abdominal terga 3, 4, dorsal aspect (anterior at top), to show color pattern. 221, terminal abdominal segments, holotype, left lateral aspect. 222, left dististyle and apex of basistyle, paratype, mesal aspect. 223, left dististyle and apex of basistyle, holotype, posterior aspect. 224, median portion of ninth abdominal tergum, male paratype, anterodorsal aspect. 225, right gonapophysis, penis, vesica and associated apodemes and muscles, right lateral aspect. 226, gonapophyses and penis, dorsal aspect. 227, terminal abdominal segments, female allotype, left lateral aspect. 228, ninth sternum and genital furca, female paratype, posteroventral aspect. Scales: a—220-221, 227; b—219, 222-226, 228.

raised in Alabama. It further recognizes my own 27-year friendship with him.

Variation.—Size variation in *C. wilsoni* is considerable for the small number of individuals available; this is especially noticeable in males. In some specimens, the darker brown lateral borders of the abdominal terga are connected across the anterior margin of each tergum; also some of the median tergal spots are a little diffuse in certain individuals. The femora of the males are not greatly incrasstae, even in the holotype which is the most robust of the series at hand. The extent to which the ninth abdominal tergum of the male is produced dorsad (or upward and backward) varies; Figure 224 shows the least projection of this mid-tergal region in any of the males available. Variation in the number of flagellomeres beyond the fusion segment has been mentioned earlier.

Relationships.—Antennal structure, body color, the shapes of the gonapophyses and ninth abdominal tergum in the male, and shapes of cerci and hypovalves in the female all indicate *Chionea wilsoni* belongs to the *scita* group. Within this species group, it most nearly resembles *C. scita,* and its geographical position suggests it may have been derived from *scita* (Map 1). From all other members of the *scita* group, males of *wilsoni* may at once be differentiated by the unique dististyles. Both males and females may be recognized by their tergal color pattern (the characteristic by means of which the female from northern Georgia was determined to be *scita* and not *wilsoni*).

Geographic Distribution.—The range of *C. wilsoni* is probably limited to the extreme southwestern Appalachian Mountains of northeastern Alabama and possibly adjacent Georgia (Map 1). Records of Chioneas belonging to the *scita* group from northeastern Georgia and further north in the Appalachians apparently all pertain to typical *scita.* Although this is the southern-



FIGS. 229-234, *Chionea macnabeana,* male. 229, pedicel and base of flagellum, right antenna, mesal aspect. 230, portion of hind tibia, near mid-length, mesal aspect. 231, left dististyle and apex of basistyle, posteroventral aspect. 232, median portion of ninth abdominal tergum, anterodorsal aspect. 233, right gonapophysis, penis, vesica and associated apodemes and muscles, right lateral aspect. 234, gonapophyses and penis, dorsal aspect. Scale: all figures.

most range for the genus (near 33°30′ to 34°N) it can still be considered essentially montane (elevations near 275-370 m, or 900-1200 ft) and cold in winter.

Seasonal Distribution.—A single early-winter generation is indicated by the available collection data. All records are for early December to late January, the coldest time of the year in mountainous northeastern Alabama.

Habitats.—All known specimens of *Chionea wilsoni* were found in leaf litter, from which they were extracted by sifting or by Berlese funnel. The forest in the type locality is the oak-hickory-pine association that is widespread at middle elevations of the southern Appalachian Mountains. In fact, with respect to climate, physiography and forest cover, the habitat of *C. wilsoni* is much the same as that for the southern Appalachian part of the range of *C. scita*.

APPENDIX 2

Male of **Chionea macnabeana** Alexander

(see p. 132)

Abdomen of male.—Posterodorsal margin of ninth tergum (Fig. 232) with broadly U-shaped median emargination wider than deep; at each side of emargination a short, thick lobe bearing 4 or 5 stout black setae. Gonapophyses (Figs. 233, 234) appearing broad in both dorsal and lateral aspects, mesal surfaces approximately vertical, joining dorsal surfaces at nearly right angle; color generally dark yellowish brown, posterior vertical margins thin, hyaline. Penis downcurved from base, its apex divided into two acuminate points, one at either side of nearly transparent terminal vesicle (endophallus?). Posteromesal lobe of basistyle (Fig. 231) subquadrate, strongly sclerotized and darkened, with yellowish hairs on inner (dorsal) surface. Dististyles brown, narrowing and curving evenly from base to acute apex (Fig. 231); setae on outer curvature sparse, mostly thick and black, but some more hair-like; mesal tooth inconspicuous, darkly sclerotized but low and rounded; no ventral tooth. Tenth segment (proctiger) grayish, not abruptly narrowed near mid-length. Abdominal terga unevenly yellowish brown to brown, without pattern; 4-6 thick, black setae along posterior edge of each; additional group of stout, black setae at posterolateral corners of terga 6-8.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

NEORTHOLOMUS, A NEW GENUS OF ORSILLINI (HEMIPTERA—HETEROPTERA: LYGAEIDAE: ORSILLINAE)

By
Steven W. Hamilton

Vol. 52, No. 7, pp. 197-234 April 8, 1983

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 7, pp. 197-234 April 8, 1983

Neortholomus, A New Genus of Orsillini (Hemiptera—Heteroptera: Lygaeidae: Orsillinae)[1]

Steven W. Hamilton[2]
Department of Entomology, University of Kansas, Lawrence, Kansas 66045

MUS COMP ZOOL
UNIVERSITY

Contents

Abstract 197
Introduction 197
Materials and Methods 198
Phylogenetic Relationships in *Neortholomus* 199
Genus *Neortholomus*, New Genus 201
Key to the Species of *Neortholomus* 202
Neortholomus arphnoides (Baker) 203
Neortholomus gibbifer (Berg) 206
"*Neortholomus jamaicensis* Species Complex" 208
Neortholomus jamaicensis (Dallas) 208
Neortholomus rubricatus (Berg) 212
Neortholomus koreshanus (Van Duzee) 215
Neortholomus nevadensis (Baker) 217
Neortholomus procerodorus, New Species 219
Neortholomus scolopax (Say) 222
Neortholomus usingeri (Ashlock) 226
Acknowledgments 228
Table 1 and Figures 230

Abstract

A new genus, *Neortholomus*, is erected to include only New World species of *Ortholomus*. This refinement is based primarily on characters of the male and female genitalia. Nine species are recognized in this genus, including a new species, *Neortholomus procerodorus*. These species are described, and external and internal characters illustrated. A key to the species is provided. A proposed phylogeny is presented and three species groups are recognized. The *scolopax* group includes *arphnoides jamaicensis koreshanus rubricatus*, and *scolopax*; the *gibbifer* group is comprised of *gibbifer*, *procerodorus*, and *usingeri*; *nevadensis* is the only member of the third species group.

Introduction

In a revision of the Orsillinae, Ashlock (1967) established the modern concepts of the included tribes and described genera. He identified *Ortholomus* as possibly polyphyletic because it lacks characters of the kind used to delimit other genera of Orsil-

[1] Contribution number 1851 from the Department of Entomology, University of Kansas, Lawrence, Kansas 66045.

[2] Present address: Department of Entomology, Fisheries and Wildlife, Clemson University, Clemson, South Carolina 29631.

lini, such as femoral spines, mesopleural overlap of the propleuron, elongate antennal segments, modified bucculae, and so forth. Ashlock stated that "species are assigned to *Ortholomus* if they have the characters of the Orsillini but lack the distinctive features of the other nine genera in the tribe."

Baker (1906) noted that the *Nysius* subgenus *Ortholomus* was "a perfectly valid genus, much better founded than are numerous others of the family Lygaeidae." Three new species and a variety of *O. longiceps* Stål 1874, were very briefly described by Baker in this same paper.

Although Baker (1906) recognized that the straight costal margin distinguished Stål's (1872) subgenus *Ortholomus* from other *Nysius* in North America, this character is not sufficient to separate *Ortholomus* from many other closely allied genera. He was unaware that the two most widely distributed species, *O. scolopax* (Say) 1831, and *O. jamaicensis* (Dallas) 1852, were already described. Two of Baker's proposed taxa, *cookii* and *uhleri,* respectively, are a common color variant and an abnormal specimen of *O. scolopax*. His descriptions were extended couplets in the keys, insufficient for the recognition of these species. Thus, Baker's revision of American *Ortholomus,* the largest and most recent treatment of the genus, is inadequate.

No comparisons of the New and Old World species of *Ortholomus* have been undertaken. Wagner (1958) included *Ortholomus* in his revision of European orsillines, but he did not compare the three named Old World species with those in the Americas.

The evolutionary relationships of *Ortholomus, Neortholomus,* a new genus recognized herein, and the other genera of the tribe Orsillini will be presented in a separate paper.

Materials and Methods

Nearly 4,800 specimens, most of which were borrowed from the institutions and individuals listed in the acknowledgments, were examined. Type specimens to be compared with one another and with other determined and undetermined specimens were borrowed when possible.

A few field and laboratory observations were made on *Neortholomus scolopax,* a widespread North American species, to supplement the study of museum specimens. The remainder of the biological data used herein has been gleaned from the literature and from label data on individual specimens.

The male and female genitalia of all species were dissected and examined for characters useful in species separation or phylogenetic analysis. In males, the paramere, aedeagus, and sperm reservoir were examined, and in females the spermatheca was studied.

For study, the aedeagus was removed from the pygophore, or male genital capsule, and inflated using osmotic pressure (Ashlock, 1957, 1967). For the most part Ashlock's 1967 method was used in this research although a mild solution of potassium hydroxide (KOH) was used as the initial wetting and macerating agent as in the 1957 method.

The technique for dissection of the spermatheca has been outlined by Ashlock (1967) and is more fully presented by Hamilton (1980). Although Ashlock (1967) notes that "no inflation is necessary" to study the structure of the spermatheca, care must be taken because inflation can occur if it is removed from KOH and placed in water. The central portion of the spermathecal pump is weakly sclerotized so that it can expand and contract with changes in osmotic pressure. For this reason, the overall length of the spermathecal pump is a very poor charac-

ter and was not used in this study. This pressure can also cause the terminal bulb to collapse or to expand and crack.

The synonymies include valid names and their synonyms, and all references since 1964. Complete lists of references can be found in Slater (1964).

Descriptions are based on the primary type in each species. Parentheses around data in the description indicates characters that could not be studied on the type specimens owing to obstruction or loss. These values or characters were obtained from other specimens, either in the type series or among the other available specimens, which were judged similar to the type.

The summaries of species distributions are based on the data gathered from the specimens I have seen. Detailed data from every specimen have been left with Dr. Peter D. Ashlock of the Department of Entomology at the University of Kansas.

The dimensions used in the descriptions are illustrated in Figure 2. The height of the mesopleural evaporative area was measured by comparing the distance from the dorsal apex of the scent gland auricle to the upper margin of the evaporative area with the distance from the dorsal apex of the auricle to the ventral margin of the metapleural callosity (Fig. 6d). The distances above the apex of the auricle were measured on a line perpendicular to the plane of the dorsal surface of the specimen and not parallel to the suture between the meso- and metapleura. The evaporative area has a granular and nonglossy appearance, which may be obscured on dirty or greasy specimens. The callosity is a smooth, often glossy, elongate area near the dorsum of the metapleuron. The length of the scent gland auricle was determined by comparing the distance from the ventral tip of the mesepimeron to the dorsal apex of the auricle with the distance from the ventral tip of the mesepimeron to the ventral margin of the metapleural callosity (Fig. 6c). These distances were taken along a line from the tip of the mesepimeron to the apex of the auricle, which is roughly perpendicular to the dorsal surface of the specimen. The mesepimeron is the area of the mesopleuron posterior to the pleural suture (Fig. 6d).

Characters used in the analysis of phylogeny are either complex derived characters or unique evolutionary innovations in the group, that is, apomorphies. When such derived characters are shared with other taxa, these synapomorphies demonstrate various phylogenetic relationships of the taxa. Such characters have been used here to infer the phylogenetic (cladistic) relationships of the species of *Neortholomus*.

Phylogenetic Relationships in *Neortholomus*

The proposed phylogeny of the included species of *Neortholomus* is presented in Figure 1. The characters used in this phylogeny, the apomorphous and plesiomorphous states of these characters, and references to illustrations of the character states are summarized in Table 1.

The genera *Ortholomus, Orsillus,* and *Sinorsillus* have been used as out-groups for comparison with *Neortholomus*. The synapomorphy establishing the holophyly of the four-genus *Orsillus* group is the presence of complex lobes on the vesica of the aedeagus (Fig. 4b; Ashlock, 1967 Figs. 3a, 4a) between the sperm reservoir and the pigmented lobe. This character and others will be discussed in another paper on the phylogeny of the Orsillini.

Based on this phylogeny the *Neortholomus* progenitor had a female with an elongate duct between the spermathecal pump and the terminal bulb, and a short, stout sclerotized basal portion of the pump, while the male had the paramere shank without a carina and the gonoporal process of the aedeagus was surrounded by little

or no inflatable membrane. The spermathecal pump of the *Neortholomus* ancestor completely lacked the dorsal flange and had a reduced basal flange, conditions unique in the *Orsillus* branch of the Orsillini.

I have recognized three species groups in *Neortholomus*, the *scolopax*, *gibbifer*, and *nevadensis* species groups. The carina on the shank of the paramere and the lack of any flange at the base of the spermathecal pump clearly delimits the *scolopax* species group, which includes *arphnoides*, *jamaicensis*, *koreshanus*, *rubricatus*, and *scolopax*. All of these species except *scolopax* have the elongate basal sclerotized area and a large evaporative area. The size of the evaporative area has not been used in this analysis because it is somewhat variable in the various species and is neither unique nor complex.

The *gibbifer* species group comprises *gibbifer*, *procerodorus*, and *usingeri*. These three species have a well developed gonoporal membrane. In *gibbifer* and *usingeri* the basal flange of the spermathecal pump is further reduced but not completely lost.

The greatly shortened duct between the spermathecal pump and the terminal bulb is not found in *nevadensis* but is shared by the *gibbifer* and *scolopax* species groups indicating these two are sister groups. *Nevadensis* shares no apomorphies with the other *Neortholomus* species, except those delimiting the genus, and thus represents the most primitive lineage in it. A very short shank of the paramere (Fig. 4a) represents an autapomorphy unique to *nevadensis* among all species of the *Orsillus* branch of the Orsillini.

Other characters which may be increasingly used in the future are the chromosome number, shape, and behavior. In a recent study of the cytotaxonomy of lygaeids, chromosome studies of four species of *Neortholomus* were reported (Ueshima and Ashlock, 1980). The chromosomes are holocentric in Heteroptera which means that the centromere is not localized (monocentric) but instead occurs along the entire length of the chromosome. If one of the chromosomes is broken, the fragments will behave normally and "perpetuate themselves during meiosis" (Ueshima, 1979). Ueshima and Ashlock (1980) found that *nevadensis* and *usingeri* have a diploid chromosome number of 14 with "five pairs of autosomes, an m-chromosome pair, and an XY sex pair," and *arphnoides* and *scolopax* have 16 chromosomes with "six pairs of autosomes, an m-chromosome pair, and an XY sex pair." They suggest that the diploid number of 16 is derived from the ancestral number of 14 chromosomes. Evidence of this conclusion is an intermediate-sized autosome pair in the 14-chromosome species that is not found in the 16-chromosome species. The 16-chromosome species have two small autosomes which are probably the fragments of the broken intermediate autosome. The large autosome is always present in *Neortholomus*.

In the Nysiini all species have 14 chromosomes (except one species with 22) while in the Metrargini 16 chromosomes is the rule except in the apparently primitive *Darwinysius*, which has a diploid number of 14 (Ueshima, 1979; Ueshima and Ashlock, 1980). They point out that the metrargine change from 14 to 16 chromosomes apparently involved the fragmentation of the large autosome and not the intermediate autosome. Therefore, the increase in chromosome number is an independent event in *Neortholomus*, unrelated to the seemingly similar change in the metrargines.

Interestingly, both of the derived 16-chromosome *Neortholomus* species are members of the well-delimited *scolopax* species group and the 14-chromosome species are found among the other groups. Although more species of *Neortholomus*

need to be studied cytogenetically, the presence of 16 chromosomes may be another synapomorphy for this entire species group. This prediction can be made since it is unlikely, given the synapomorphies above, that *scolopax* and *arphnoides* share an ancestor with 16-chromosomes which is not also shared with the other three members of the *scolopax* species group.

A new genus, *Neortholomus*, is proposed herein to comprise the New World species of *Ortholomus* Stål *sensu lato*. *Ortholomus sensu stricto* will consist of the three Old World species: *punctipennis* (Herrich-Schaeffer), *carinatus* (Lindberg), and *jordani* Hobertlandt. I have been able to study specimens only of *punctipennis*, the type species, but I assume that these three species are very closely related. In light of the substantial variation known in widely distributed *Neortholomus*, it is possible that *carinatus* and *jordani* are junior synonyms of *punctipennis*. In his study of the Palaearctic *Nysius* complex, Wagner (1958) recognized these as species, but it seems clear from his characters that they are, at least externally, very close. For these reasons, as well as their overlapping Old World distributions, I have assumed that the genitalic characters for these three species will be similar, if not identical.

Ashlock (1967) gave characters to distinguish *Ortholomus s. l.* from other genera of Orsillinae. In a paper on the phylogeny of New World Orsillini to follow this paper more characters of this nature will be given for *Ortholomus s. s.* and it will be redescribed in keeping with the elevation of the New World members to generic rank.

No single external character has been found which distinguishes all of the species of *Neortholomus* from *Ortholomus punctipennis*. These two genera can readily be separated by differences in characters of the male and female genitalia.

The spermatheca of *Ortholomus* has well-developed flanges at both ends of the spermathecal pump, as well as a convoluted duct of moderate length to the terminal bulb and a long unsclerotized portion (Ashlock, 1967 Fig. 8c). In *Neortholomus*, the spermathecal pump has no distal flange and a greatly reduced or lacking basal flange (Fig. 3). The duct to the terminal bulb is much shorter in *Neortholomus* than in *Ortholomus* (except in *N. nevadensis*, Fig. 3c), as is the basal unsclerotized duct.

Other useful characters that distinguish *Ortholomus* and *Neortholomus* are found on the aedeagus. The gonoporal process of *Ortholomus* (Ashlock, 1967 Fig. 4a) is a long spiral with no attached inflatable membrane. *Neortholomus* has a relatively short gonoporal process with varying amounts of attached membrane extending to near the distal end (Figs. 4b-d, i, j).

In *Neortholomus* the sperm reservoir of the aedeagus (Figs. 5c, d) appears to be in a relatively primitive condition for the Orsillini. The body of the sperm reservoir is reduced or lacking, and the wings are fused dorsally over the ejaculatory duct. The lateral portions of the wings may or may not extend ventrally for a short distance. In *Ortholomus* (Figs. 5a, b) the lateral portions of the wings extend ventrally and fuse beneath the ejaculatory duct to form a complete ring or collar about the duct, a derived condition.

The uniqueness and homogeneity of the spermathecae and the other genitalic characters of *Neortholomus* indicate that this group of species is a monophyletic group deserving full generic status.

Genus *Neortholomus*, New Genus

Type species: *Lygaeus scolopax* Say, 1831.

Generic description: Form moderately elongate to elongate, not depressed; body covered with short, pale, appressed pubescence, in some species mixed with

sparse, short to moderately long, erect, pale hairs. Head moderately stout to elongate, produced before eye for distance slightly greater than length of eye to about two times length of eye; width of head including eyes less than width at posterior margin of pronotum; antenniferous tubercle not extending beyond point of insertion of antenna. Buccula impunctate, high anteriorly, tapering to near base of head or to point short of this (usually about mid eye level) and continuing to near base of head as a low carina; labium extending to point between middle and hind coxa *(procerodorus)* or nearly to apex of abdomen *(koreshanus)*. Vertex low, when viewed laterally, level with high point of eye or extending above eye one-fourth height of eye, frequently more flattened between eyes, sometimes strongly convex *(arphnoides)*, with carina extending anteriorly from ocellus paralleling margin of eye to base of antenniferous tubercle; eye sessile to substylate, always prominent.

Scutellum with a moderate to pronounced and swollen Y-shaped elevation, apex of scutellum acute and slightly upturned. Evaporative area small, only surrounding scent gland auricle on metapleuron, or larger, including mesepimeron along posterior edge of mesopleuron and nearly attaining lateral callosity on metapleuron. Scent gland auricle typically short and broad, about one-third height of metapleuron, sometimes elongate and narrow being about one-half height of metapleuron. Hemelytron complete, partly exposing connexivum laterally, terminating short of or slightly beyond tip of abdomen, corium impunctate; costal margin straight, coincident with vein R + M at least to level of apex of scutellum; branch M of R + M intersecting apical margin of corium at a point closer to intersection of vein Cu than of vein R with apical margin of corium, branches often obscure, corium nearly clear to opaque light-brown between veins; vein 1A of membrane frequently turned toward vein Pcu, cell never completely closed, membrane with numerous transverse wrinkles.

Spermatheca lacking distal flange on pump, distal edge rounded, basal flange very reduced or lacking, duct between pump and bulb usually short, occasionally longer *(nevadensis)*. Aedeagus with complex lobes on vesica between sperm reservoir and pigmented lobe, gonoporal process moderately inflatable to lacking; sperm reservoir narrow, simple platelike structure dorsally positioned over sperm duct, connected by narrow duct distally on reservoir, sides occasionally turned ventrally, but never joining below duct.

Characteristics to separate this genus from *Ortholomus* are in the genitalia, as outlined above.

Included species: *arphnoides* (Baker), 1906, *Ortholomus; gibbifer* (Berg), 1892, *Nysius; jamaicensis* (Dallas), 1852, *Nysius; koreshanus* (Van Duzee), 1909, *Belonochilus; nevadensis* (Baker), 1906, *Ortholomus; procerodorus* Hamilton, new species; *rubricatus* (Berg), 1879, *Nysius; scolopax* (Say), 1831, *Lygaeus; usingeri* (Ashlock), 1972, *Ortholomus*.

Etymology: *Neos,* Greek, meaning new. In reference to the elevation of the included species to a new genus near *Ortholomus* and to the New World distribution of the genus.

Key to the Species of *Neortholomus*

1 Height of evaporative area from apex of auricle to margin of evaporative area directly above at least half distance from apex of auricle to metapleural callosity (Figs. 6c, d) 2

— Height of evaporative area from apex of auricle to margin of evaporative area directly above less than half distance from apex of auricle

to metapleural callosity (Figs. 6a, b) 6

2(1) Third labial segment reaching beyond hind coxae; head elongate, width of head including eyes subequal to length of head before ocelli (Figs. 7a, d); Florida, Isle of Pines ..... *N. koreshanus*

— Third labial segments sometimes attaining abdomen between hind coxae, but never distinctly exceeding coxae; head not so elongate, head width including eyes at least 1.2 times length of head before ocelli (Figs. 7b, c, e-h) 3

3(2) Scent gland auricle elongate, distance from ventral tip of mesepimeron to apex of auricle about two-thirds distance from ventral tip of mesepimeron to metapleural callosity (Fig. 6c); Peru ..... *N. procerodorus,* n. sp.

— Scent gland auricle not elongate, distance from ventral tip of mesepimeron to apex of auricle about half or less distance from ventral tip of mesepimeron to metapleural callosity (Figs. 6a, b, d) 4

4(3) Second antennal segment shorter than interocular distance, eyes small and sessile, vertex strongly convex between eyes (Figs. 7b, e); California ..... *N. arphnoides*

— Second antennal segment longer than interocular distance, eyes moderately large and substylate, head flat or slightly convex between eyes (Figs. 7c, f) 5

5(4)[3] Third labial segment usually shorter than anteocellar head length; California, Arizona, and Florida south to Argentina, Caribbean Islands, some Pacific islands ..... *N. jamaicensis*

— Third labial segment usually greater than anteocellar head length; South America ..... *N. rubricatus*

6(1) Evaporative area reduced, extending posterior of auricle a distance less than width of auricle, covering only small part of mesepimeron (Fig. 6b); Galapagos .... *N. usingeri*

— Evaporative area extending posterior of auricle by a distance greater than width of auricle, covering mesepimeron (Fig. 6a) 7

7(6) Scutellum swollen, in lateral view, slightly higher than pronotum (Fig. 6e); Argentina, Brazil, Chile ..... *N. gibbifer*

— Scutellum not swollen, in lateral view, level with pronotum (Fig. 6f) 8

8(7) Viewed with vertex of head level, ocelli on or before imaginary line drawn through posterior margins of eyes, head margin behind eye nearly perpendicular to imaginary median longitudinal line of head; eyes large and substylate (Fig. 7h); western United States .. *N. nevadensis*

— Viewed with vertex level, ocelli posterior to imaginary line drawn through posterior margins of eyes, head margin behind eye oblique to imaginary median longitudinal line of head; eyes smaller and only slightly substylate (Fig. 7g); southern Canada south to Guatemala .... *N. scolopax*

[3] Debatable species distinction—see text.

Neortholomus arphnoides (Baker)

Ortholomus arphnoides Baker, 1906, 140; Slater, 1964, 335; Ashlock, 1967, 6, 15, 34.

Nysius arphnoides; Banks, 1910, 62.

The acute head, strongly convex vertex and relatively small, sessile eyes easily distinguish this small, somewhat elongate Californian species from all other species

of *Neortholomus*. The hemelytra are well developed, the membrane clearly exceeding the apex of the abdomen. The antennae are short and stout with the scape distinctly not exceeding the tylus. Specimens of *N. jamaicensis* from California may be confused with specimens of *N. arphnoides* but can readily be separated when the characters of the head and antennae are carefully considered.

Structure: Head strongly convex between eyes, obscurely punctate; clothed densely with short appressed hairs about twice as long as an ocellar diameter; eyes small and sessile, in dorsal view slightly less than hemispherical, highest point of eye level with head at base of eye and distinctly lower than vertex; head length 0.85, width 0.85, anteocular length 0.44, interocular space 0.54, interocellar space 0.34, eye length 0.22, eye width 0.17, eye height 0.27. Buccula elevated anteriorly, gradually narrowing posteriorly to mid-eye level without abrupt change in width, extending anterior of jugum a distance equaling one-third length of scape; labium just attaining third visible abdominal segment, first segment nearly reaching thorax, second segment of labium reaching just beyond fore coxae, third segment attaining point between hind coxae, segment lengths from base 0.58, 0.58, 0.61, 0.43. Antenna with sparse, fine erect hairs, shorter and more dense distally, scape not exceeding tylus, shorter by distance equaling scape diameter, segment lengths from base, 0.26, 0.37, 0.37, 0.44.

Pronotum with pubescence as on head, erect hairs on front lobe longer by about one-half and more erect, punctation moderate and irregular, distance between punctures 0.25 to 1.0 × diameter of a puncture; pronotum evenly rounded and slightly depressed at callosities, posterior lobe less convex, sides slightly swollen at callosities, remaining margin straight to posterior angle; length 0.71, width 1.16. Scutellum with vestiture as on head, and punctation as on pronotum; Y-shaped carina evident, upper arms moderately swollen, stem of "Y" very low and outlined by punctures, length 0.54, width 0.70. Metapleuron slightly swollen at callosity; distance between highest point of scent gland auricle to upper edge of evaporative area directly above about one-half distance from auricle to callosity directly above, evaporative area on mesepimeron, extending dorsally along intersegmental suture nearly to dorsal edge of pleuron, evaporative area with 20-distinct punctures each with one thin hair.

Hemelytron exceeding abdomen; corium moderately clothed with short, curved, appressed hairs, basal one-third of costal margin with erect laterally projecting hairs, longest anteriorly, decreasing steadily in length posteriorly, length of claval commissure 0.46, length of corium 1.58. Membrane with veins indistinct; basal length to level of corial apex 0.75, apical length from corial apex 1.02.

Abdomen with moderate vestiture of short appressed hairs and sparse vestiture of short erect hairs; connexivum narrowly exposed lateral to corium, spiracles obscure.

Color: Head with brownish-yellow broad longitudinal band from vertex between ocelli to tylus and laterally onto jugum; buccula, distal and ventral antenniferous tubercle, and ring about base of eye brownish-yellow, remainder of head blackish-brown. Antenna pale basally with distal segments darker, fourth segment brown.

Pronotum generally yellow, punctures and scattered areas slightly darker, callosities blackish-brown with surrounding area dark, wide area laterally and narrow anterior margin light; yellow area of posterior lobe contiguous with triangular area in posterodorsal corner of propleuron. Acetabulum and posterior propleural area pale yellow to yellow, anterior prosternum

yellow to brown, remainder of propleuron and prosternum dark brown to black. Meso- and metapleuron similarly dark; acetabula, scent gland auricle, and narrow anterior portion of evaporative area along intersegmental suture pale. Scutellum dark brown, slightly lighter posteriorly on stem of Y-shaped carina.

Corium and clavus light brownish-yellow, claval commissure and irregular areas along veins slightly darker, corial apex red to pale reddish-brown; membrane slightly milky, nearly hyaline, without dark markings.

Abdomen ventrally with basal four segments and dorsolateral area of sixth segment blackish-brown, posterior segments yellowish-brown.

Legs generally yellowish-brown, coxae slightly darker basally; femur with irregular, slightly contrasting spots, tarsi slightly darker distally.

Size: Male, length 3.6-4.2, pronotum width 1.0-1.2; female, length 4.0-4.9, pronotum width 1.1-1.4.

Types: I have seen the types of *Orthololomus arphnoides* Baker through the kindness of Dr. David A. Guthrie of the Claremont College, Claremont, California. One of these specimens has been labeled as the holotype although Baker failed to designate a holotype and his specimens therefore represent a syntypic series. The lectotype here selected is a female in Baker's collection which bears the following three labels, the uppermost first: "Mts. near/Claremont/Cal. Baker," "3213" and on a red label "*Ortholomus/arphnoides/* Baker." The specimen is point-mounted and is now preserved at the California Academy of Science, San Francisco, California.

Specimens with Baker's original labels, "Mts, near Claremont Cal. Baker" or "Claremont Cal. Baker" are considered paralectotypes for these specimens were probably before Baker when he described the species. There are three such specimens (1 male, 2 females) in the Baker Collection with the lectotype, others are in the Snow Entomological Museum, University of Kansas (1 male, 1 female), the California Insect Survey at the University of California in Berkeley (1 male) and the Los Angeles County Natural History Museum (1 male, 1 female).

Variation: This species usually has a dark overall appearance. Frequently the head, anterior lobe of the pronotum, and venter are nearly totally black but occasional individuals are paler, having brown in these same areas. Most specimens are intermediate in color, being similar to the lectotype described above.

The beak length varies somewhat. Shorter beaks only reach the third segment of the abdomen while the longest attain the fifth abdominal segment.

Specimens examined: 148 males and 191 females.

Distribution: All known specimens of this species were collected in California. Specimens have been examined from the following counties: Alameda, Contra Costa, Inyo, Kern, Kings, Los Angeles, Modoc, Monterey, Orange, Riverside, San Benito, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Sonoma, Tulare, and Ventura. Several of the more peripheral records, from Modoc (Buck Creek just east of Willow Ranch), Inyo (Big Pine), and San Diego (Jacumbo) counties, indicate that the range of *N. arphnoides* may extend outside of California into Oregon, Nevada, and northwestern Mexico.

Food Plants: Of the 60 specimens of *N. arphnoides* with plant association data, 35 in four series were labelled *Salvia mellifera,* two in a single series were labelled *Salvia spathacea,* two in another series were labelled *Salvia* and 17 in another series were labelled "sage," the common name for *Salvia*. Single specimens were

reported on *Rosa woodsii* var. *gratissima* (Rosacea), *Atriplex semibaccata* (Chenopodiacea), *Baccharis* (Compositae), and *Eriogonium* (Polygonaceae). Van Duzee (1914) reported this species as being "found commonly on the flower heads of the black sage *(Salvia mellifera)* during May and June." Torre-Bueno (1946) also recorded black sage as the food plant and Blatchley (1934) found *N. arphnoides* the "most common winter bug about Los Angeles, occurring in numbers on dead weeds . . ."

It appears that *Salvia mellifera,* black sage, is the most common food plant. Several specimens, however, have been collected outside the range of *S. mellifera* —Coast Range from Contra Costa and western Stanislaus counties in northern Lower California (Munz and Keck, 1959) —especially those specimens from Tulare, Tulare County and Buck Creek, Modoc County. In these peripheral localities, other species of *Salvia* are likely to be the primary food plant. Like most seed-feeding lygaeids, *N. arphnoides* is undoubtedly opportunistic, feeding on the seeds of other plants when the seeds of the primary food plant are not available. In the laboratory this species has been reared on sunflower seeds and water (Ashlock, 1967).

Neortholomus gibbifer (Berg)

Nysius gibbifer Berg, 1892, 155; Slater, 1964, 280.
Ortholomus gibbifer; Ashlock, 1967, 34.
Ortholomus gibbus (sic); Ashlock, 1972, 93.

The greatly swollen scutellum distinguishes this species from others of *Neortholomus.* The strongly declivate head and pronotum, moderate sized substylate eyes, flattened vertex, broadly exposed connexiva and longitudinal pale line on the head, pronotum and scutellum are useful in its identification.

Structure: Head nearly flat between eyes, slightly convex between ocelli, obscurely punctate, clothed densely with short silver hairs and very sparsely with long erect hairs about one and one-half times diameter of an ocellus; eye large, hemispherical, appearing slightly stalked above and appressed to head below, highest point of eye higher than head at base of eye, just below level of vertex in lateral view; head length 1.11, width 1.21, anteocular length 0.44, interocular space 0.77, interocellar space 0.24, eye length 0.34, eye width 0.22, eye height 0.31. Buccula elevated anteriorly gradually narrowing posteriorly to mid-eye level and ending with abrupt curve to head, extending beyond anterior of jugum, only slightly, the distance less than apical diameter of scape; labium short (reaching to point between middle and hind coxae), first segment not attaining thorax, second segment attaining point between fore coxae (third segment just reaching anterior edge of middle coxae); segment lengths from base 0.54, 0.56 (0.53, 0.36); (antenna with fine erect pubescence as on head), sparse on basal segments (dense on fourth segment), scape just exceeding tylus; segment lengths from base 0.31, 0.70 (0.65, 0.63).

Pronotum with pubescence as on head, punctation moderate and irregular, distance between punctures from 0.5 to 1.5 × a diameter of a puncture; strongly depressed across callosities, anterior and posterior lobes convex transversely, posterior lobe strongly convex longitudinally, lateral margin moderately swollen laterally at callosities, remaining margin straight to posterior angle; length 1.07, width 1.77. Scutellum vestiture as on head and prothorax, punctation dense on posterior one-fourth, distance between punctures 0.5× or less a puncture diameter, Y-shaped carina prominent, upper arms greatly swollen covering anterior three-fourths of scutellum and projecting dorsally higher than

posterior lobe of pronotum, stem of "Y" short and low, outlined by punctures, length 0.80, width 1.00. Metapleuron swollen at callosity; distance between highest point of auricle and dorsal margin of evaporative area directly above distinctly less than one-half distance from auricle to callosity directly above, evaporative area on mesepimeron and extending dorsally along intersegmental suture to level of metapleural callosity; evaporative area with about 20 distinct punctures each with a thin hair.

Hemelytron exceeding abdomen; corium and clavus clothed densely with appressed hairs and sparsely with erect hairs, shorter than on scutellum, erect laterally directed hairs on basal one-third of costal margin becoming progressively shorter posteriorly; length of claval commissure 0.53, length of corium 2.41; membrane with veins distinct, basal length to level of corial apex 1.00, apical length from corial apex 1.19.

Abdomen with moderately dense vestiture of short appressed hairs interspersed with occasional erect hairs; connexivum broadly exposed lateral to corium, spiracles obscure.

Color: Head ground color light brown, dark around ocelli and along carina to mid-eye level, pale median longitudinal band on posterior one-half of vertex, pale around base of eye and on tylus; dark reddish-brown on lorum anterior to antenniferous tubercle, laterally on tubercle, at base of head posterior to buccula; pale yellow on gena below eye and on buccula, antenna yellow, apical one-half pedicel brown.

Pronotum ground color yellow to light brown with pale median longitudinal band medially, continuous with pale band on vertex and scutellum, callosities black, posterior angle brown; propleuron colored as pronotum; prosternum dark brown between acetabulae. Meso- and metapleuron generally pale brown to yellow; acetabulae, mesopleural evaporative area, auricle, and posterior metapleural flange pale yellow. Scutellum brown to dark brown, posterior corner and median longitudinal band pale.

Corium and clavus brownish-yellow to pale yellow, darker areas on claval commissure and irregularly on veins; membrane slightly milky with pale brown infuscations in central area between veins.

Abdominal venter brindled with brown and red markings; connexival segments brown with posterior one-third yellow.

Legs yellow with brown spots, some spots fused, forming bands around leg; brown basally on tibia.

Size: Male, length 4.1-4.8, pronotum width 1.3-1.6; female, length 4.2-5.2, pronotum width 1.4-1.8.

Type: Berg's type is a single female specimen from the "Province of Cordoba, Republic of Argentina" (Berg, 1892). Berg wrote that he waited 16 years before describing the specimen in hopes that more specimens might be obtained. The type has the following labels, the uppermost first, "♀" on small white label, "Typus" printed in red on a white label with red borders, "Cordoba" printed in black on a dark green label, "Nysius gibbifer 1891. Berg" in Berg's handwriting on a white label with red border, and "C J Drake/ Coll. 1956" on white label. It is in the Drake Collection at the U.S. National Museum of Natural History in Washington, D.C.

Variation: The holotype is a pale specimen, apparently bleached with age, but the general color patterns are present and similar to dark specimens I have seen. The pale longitudinal fascia on the head, pronotum, and scutellum is always present although it tends to be somewhat obscure on very dark specimens. I have seen several specimens from Chile which are nearly black in general coloration. There is a

continuous range of color in this species between the pale brown type and the very dark brown Chilean specimens.

The beak length varies little in this species, always ending between the hind coxae. This is a generally uniform species except for the considerable variation in color and moderate size variation.

Specimens examined: 22 males, 13 females and 1 nymph.

Distribution: Northern Argentina (Catamarca, Cordoba, Jujuy, Sante Fe, San Luis, and Tucuman provinces), southern Brazil (Santa Catarina, state), and north central Chile (Aconcagua, Atacama, and Coquimbo provinces).

Food Plants: Nothing is known about the biology of this species. One small series—three males, one female, and one nymph—were taken on *Verbena officinalis* (Verbenaceae). Interestingly, this is the same genus of plant on which *N. usingeri* and *N. jamaicensis* have been collected. Specimens have been collected in January, February, March, June, October, November, and December.

"*Neortholomus jamaicensis* Species Complex"

A group of possible species, which is informally named after the oldest name, *Neortholomus jamaicensis* (Dallas) 1852, presents difficult problems of species limitations. Workers who have studied this group before have had similar problems. Other named members of the *jamaicensis* species complex are *Nysius spurcus* Stål, 1859, *Nysius rubricatus* Berg, 1879, and *Nysius providus* Uhler, 1894. Because of the wide distribution of members of this complex and variation in the characters, it is difficult to determine the limits of specific variation and so the validity of some of these names, but members of the complex are clearly distinct from other species of *Neortholomus*.

The description of the *Nysius jamaicensis* holotype below is included since it is the oldest species with which all other members of the complex must be compared. I consider *Nysius rubricatus* to be a valid species and *Nysius spurcus* and *Nysius providus* to be junior synonyms of *Neortholomus jamaicensis,* these points being treated below. All members of the complex, except *rubricatus,* key to *N. jamaicensis* in the key to species.

Neortholomus jamaicensis (Dallas)

Nysius jamaicensis Dallas, 1852, 555-556.
Nysius spurcus Stål, 1859, 234.
Nysius providus Uhler, 1894, 182-183.
Ortholomus jamaicensis; Van Duzee, 1907, 6; Slater, 1964, 335-336; Ashlock, 1967, 34; Alayo, 1973, 34.
Ortholomus spurcus; Ashlock, 1967, 34.

Neortholomus jamaicensis (Dallas) is distinguished by the size of the evaporative area, length of the scent gland auricle, and the shape and size of the head and eyes. This species is most like *N. procerodorus,* but the length of the scent gland auricle as well as details of the spermatheca, aedeagus, and clasper separate it, as noted under the discussion of *N. procerodorus.* Its separation from *N. rubricatus* is discussed in detail below.

Structure: Head very slightly convex between eyes, punctation obscure, heaviest posteriorly; moderately dense vestiture with very short pale erect hairs and occasionally with anteriorly directed erect hairs; eyes large and hemispherical, appearing slightly stalked above and appressed to head below, top of eye slightly higher than head at base of eye and at vertex; head length 0.99, width 1.05, anteocular length 0.49, interocular space 0.63, interocellar space 0.31, eye length 0.31, eye width 0.20, eye height 0.31. Buccula elevated anteriorly, gradually narrowing posteriorly to mid eye level without abrupt

change in width, extending beyond anterior of jugum for distance equaling about one-third length of scape; labium reaching second abdominal segment, first segment not attaining thorax, second segment reaching posterior edge of fore coxae, third segment attaining posterior edge of middle coxae, segment lengths from base 0.63, 0.61, 0.61, 0.49. Antennae with erect distally directed short hairs, hairs sparse on scape and pedicel, slightly more dense on third segment, dense on fourth, scape nearly attaining tip of tylus; segment lengths from base 0.31, 0.71, 0.68 (0.70).

Pronotum with pubescence as on head, moderately punctate, distance between punctures 0.5 to 1.0× diameter of a puncture, punctation more dense anteriorly especially along mid line; surface nearly flat and slightly depressed at callosities, posterior lobe convex; lateral margins distinctly swollen at callosities, slightly concave between callosity and posterior angle; length 1.02, width 0.92. Scutellum vestiture as on pronotum and head, punctation more dense, distance between punctures 0.5× or less the diameter of a puncture, each puncture also appearing slightly larger; Y-shaped carina distinct, arms moderately swollen, stem very low, outlined by punctation; length 0.70, width 0.92. Metapleuron swollen at callosity, distance between highest point of auricle to upper edge of evaporative area directly above approximately two-thirds the distance from auricle to callosity directly above, evaporative area on mesepimeron extending dorsally along intersegmental suture to level of callosity, evaporative area having about 25 distinct punctures, each with a single thin hair.

Hemelytron exceeding abdomen; corium and clavus clothed moderately with short, curved, appressed hairs, erect hairs lacking, costal margin with laterally projecting curved hairs on basal one-half becoming progressively shorter posteriorly; length of claval commissure 0.54, length of corium 2.43. Membrane with veins indistinct; basal length to level of corial apex 0.95, apical length from corial apex 1.24.

Abdomen with dense vestiture of very short, appressed hairs and sparse vestiture of erect, slightly longer, posteriorly directed hairs; connexivum narrowly exposed laterally, spiracles obscure.

Color: Head ground color pale brown, darker brown area around ocellus extending forward along carina to mid-eye level and outlining base of tylus, narrow margin about base of eye and median stripe on posterior one-half of vertex pale; buccula pale yellow, dark brown on venter of head surrounding buccula from lorum to near base of head, pale to thorax, lateral area of antenniferous tubercle from tip to eye brown, pale area below eye to dark venter. Antenna brown, slightly darker near joints, fourth segment darker.

Pronotum ground color pale brown, callosities blackish-brown, posterior lobe with indistinct checkerboard pattern formed by irregular, slightly dark areas, posterior angles dark; propleuron with callosity dark brown, circular area between callosity and base of acetabulum yellowish-brown, remainder pale yellow; prosternum dark brown between acetabulae. Mesopleuron pale with small dark spot on upper one-third and large spot on lower one-third, dark brown ventrally; metapleuron brown laterally with callosity and small area in upper evaporative area darker, auricle slightly lighter than evaporative area; second and third acetabula and posterior metapleural flange pale, nearly white. Scutellum generally brown to dark brown, pale posteriorly and along posterior one-third of sides.

Corium and clavus generally very pale, brown on some veins, especially posteriorly, irregular brown spots on claval commissure and on clavus, apex with irregular markings of red and reddish-brown; mem-

brane very slightly milky with faint, irregular infuscations near center.

Abdomen brindled with brown, ventral one-third slightly darker, no distinct pattern.

Legs pale yellow overall, femora with brown spots, some fused, trochanter pale, coxae pale mesally and distally, darker laterally, second and third tarsomeres darker.

Size: Male, length 3.9-4.8, pronotum width 1.1-1.3; female, length 3.8-5.8, pronotum width 1.1-1.7.

Type: Mr. W. R. Dolling of the British Museum (Natural History), London, lent me the type of *Nysius jamaicensis* Dallas for study. It is a single female with a small round white label with an orange border and the word "Typus," another small round white label with handwritten numerals about the edge reading in the clockwise direction "40, 3, 324, 4," and an elongate rectangular white label with "15. Nysius Jamaicensis," printed on it. Types of the synonymous names are discussed in a separate section below.

Variation: Considerable structural variation in *N. jamaicensis* makes the recognition of species limits difficult. Substantial color variation occurs in the species as well, but none stands as a distinct cluster, instead the variants grade from one to the next. Four specimens from Clipperton Island off the Pacific Coast of Mexico have a dark brown pattern on a pale, almost cream, ground color. In many other specimens the same mottled pattern occurs but on a light brown background. The other extreme in color of this species is the evenly colored, light-brown individuals which are similar to the type of *Nysius spurcus* Stål. Overall, no pattern of distribution in these color patterns was noted.

A fascia similar to that found on most *N. rubricatus* is also occasionally found in *N. jamaicensis*. It varies from obvious to barely discernible.

The antenna is somewhat shorter in the northwestern part of its range (western and southwestern U.S.), being slightly shorter than those described on the type but not as short as those of *N. arphnoides*. This character, like the others, is not clear-cut, and all intermediate forms can be found.

Although the color and antennal characters are quite variable, they are only slightly more so than in *N. scolopax* and do not seem beyond the limits of species variation. But the variability of the beak in the *N. jamaicensis* species complex appears to be beyond these limits. In the northern part of the range, the United States, the Caribbean, and Mexico, little problem is found, the beak length agreeing relatively closely with the type of *N. jamaicensis*. In southern Mexico and Central America longer beaks are more common. In regions north of Panama this increase in beak length is not great, but from Panama south, specimens with beaks similar in length to those on the types of *Nysius rubricatus* Berg are more common. In *N. rubricatus,* the length of the third labial segment is greater than the length of the head before the ocelli, whereas in *N. jamaicensis* the third labial segment is shorter than the anteocellar head length. In the discussion of *N. rubricatus* I have compared the types of the species to *N. jamaicensis* and a description is included below.

Specimens examined: 1255 males and 1103 females.

Distribution: Coast Range counties of California (Humboldt County and south), southern Arizona (Santa Cruz County), southern Texas (Cameron, Hildago, Starr, and Willacy counties) and southern Florida (Dade and Monroe counties), south through the Caribbean islands, Mexico, and Central American to Peru, Bolivia, Paraguay, northeastern Argentina (Corrientes and Formosa provinces), and south-

ern Brazil (Santa Catarina, state). Not known from Chile and Uruguay. Records known from Clipperton, Clarion, Socorro, and Tahiti islands in the Pacific. Specimens are known from coastal regions up to 10,000 feet in one example from Mexico.

Food Plants: I have seen specimens with the following plant data (number of collections : number of specimens): *Cleome spinosa* (Capparidaceae) (1 : 1), *Baccharis* sp. (Compositae) (1 : 3), *Eupatorium adenophorum* (Compositae) (2 : 14), *Cucurbita moschata* (Cucurbitaceae) (1 : 1), *Ocimum sauve* (Labiatae) (1 : 1), *Stachys californicus* (Labiatae) (1 : 5), *Salvia splendens* (1 : 3) and *S. xalapensis* (1 : 1) (Labiatae), *Ribes hesperia* (Saxifragaceae) (1 : 2), *Solanum tuberosum* (= *Jamesii,* Solanaceae) (1 : 4), *Lippia* sp. (Verbenaceae) (1 : 1), *Verbena prostrata* (Verbenaceae) (1 : 1), and *Vitex pyramidata* (Verbenaceae) (1 : 1). One collector included on a note with the specimen, "On a species of *Hyptis* (Labiatae) growing in damp and somewhat shady place. Others were seen on same plant but escaped, they conceal themselves on the flower head." The habit of hiding on the flower head has been observed in *N. scolopax* and may be characteristic of all *Neortholomus.*

Synonymized species: *Nysius spurcus* Stål has presented some minor problems primarily concerning distribution. Usinger (1941) synonymized *N. spurcus* with *Ortholomus jamaicensis* (Dallas). I have seen Stål's type specimens from the Swedish Museum of Natural History through the courtesy of Dr. Persson. I have compared these specimens with the type of the Dallas species and agree with Usinger.

In the type series sent to me by Dr. Persson were two females from "Taiti" and a male from Honduras. Stål (1859) in the original description, also included "Rio Janeiro" as a locality. Dr. Persson has been unable to locate such a specimen or specimens. He has suggested that Stål, after publishing the original description of *N. spurcus,* may have removed the "Rio Janeiro" specimen from the type series thinking it was not conspecific. In the Enumeratio Hemipterorum IV (1874), Stål mentions only "Insula Taiti" as the locality for *Nysius spurcus.*

No lectotype has been selected for *Nysius spurcus* Stål. Although the two female specimens are marked as "Typus" and "Paratypus," I do not believe these labels were placed by Stål. As lectotype of *Nysius spurcus,* I have chosen the female specimen with the labels "Taiti," "Kinb.," "spurcus Stal" in Stål's handwriting, "Typus" on a red label, "50 75" on a red label and "Riksmuseum Stockholm" on a light green label. Included as paralectotype are a female specimen with the labels "Taiti," "Kinb.," "spurcus" (a recent label), "Paratypus" on a red label, "51 78" on a red label, "Riksmuseum Stockholm" on a light green label; and a male specimen labeled "Honduras" and "Hjalmarson" both in Stål's handwriting, "52 78" on a red label and "Riksmuseum Stockholm" on a light green label. Although the male specimen was not marked as a type, it is in the type series and Stål mentioned a male specimen in the original description. Stål stated that he had sent a specimen from Honduras to "Dom Hjalmarson." Judging from these facts, I believe this male belongs in the type series.

The major difference between the types of *spurcus* and *jamaicensis* is the paleness of the Stål types compared to that of Dallas. This pale coloration is not unusual in *Neortholomus jamaicensis* and I consider this individual variation.

The major problem with *N. spurcus* is the question of the accuracy of the "Taiti" locality data on the two female specimens. Tahiti is an unlikely locality for an otherwise New World species. The

only other Pacific islands on which this species has been found are Clarion, Clipperton, and Socorro islands, all within 800 miles of the west coast of Mexico.

Usinger (1941) wrote, "Locality records for the Eugenies Resa expedition have proved to be notoriously inaccurate and several competent collectors . . . have failed to turn up any Orsillini in the Society Islands." For reasons of this sort, Stål's record from "Taiti" has been thought erroneous and the specimens considered mislabeled. In material from the United States National Museum of Natural History, however, I have seen a single female specimen of *Neortholomus jamaicensis* from near the Fantana River in Tahiti collected in 1961 by J. F. G. Clarke. I have compared this specimen with the types of *N. jamaicensis* and *N. spurcus*. The Tahiti specimen has a slightly paler head and slightly darker pronotum than the *N. jamaicensis* type and is generally darker than the *N. spurcus* type. No other differences could be found. The color differences are easily within the limits of species variation.

It is possible that the species was introduced to the islands by early traders who sailed between the New World and the South Pacific islands. Natural introduction to the islands seems unlikely over these distances. There is no evidence of populations between the New World and Tahiti on islands that might have acted as "stepping stones."

I have seen the holotype of *Nysius providus* Uhler at the U.S. National Museum of Natural History. This specimen is clearly a *Neortholomus jamaicensis*. This species was synonymized by Distant (1901). Although I have not seen the entire type series, it is likely that it includes specimens of both *N. scolopax* and *N. jamaicensis* judging from the distribution given by Uhler in the original description. His statement of distribution for *providus* was "North American from Quebec to Arizona, from thence it spreads into Mexico and Central America, and following south it is found on the Isthmus of Panama, and in Colombia and northern Brazil. In the West Indies it occurs in Trinidad, Grenada, St. Vincent, Porto Rico, San Domingo, and Cuba, and from thence it extends through Florida into all of the eastern states as far as Maine" (Uhler, 1894). Neither of the above-mentioned species has such an extensive distribution but the combination of the two would.

Neortholomus rubricatus (Berg)

Nysius rubricatus Berg, 1879, 102-103.
Belonochilus rubricatus; Kiritshenko, 1931, 16; Slater, 1964, 236.
Ortholomus rubricatus; Ashlock, 1967, 34.

Neortholomus rubricatus is most similar to *N. jamaicensis* and *N. koreshanus*. The length of the third labial segments is greater than the preocellar head length in *N. rubricatus* whereas the preocellar head length is greater in *N. jamaicensis*. *Neortholomus rubricatus* usually has a pale fascia along the midline of the head, pronotum, and scutellum.

Neortholomus koreshanus has a much longer head and labium than does *N. rubricatus*. For a more detailed discussion of the diagnostic characters see the section on variation for *N. jamaicensis* above and for *N. rubricatus* and *N. koreshanus* below.

Structure: Head slightly convex between eyes, obscurely punctate; (moderately dense vestiture of very short, pale, appressed hairs and very few erect, anteriorly directed hairs); eyes moderate sized, less than hemispherical, appearing slightly stalked above and appressed to head below, top of eye level with head at base of eye and lower than vertex; head length 1.02, width 1.00, anteocular length 0.55, interocular space 0.62, interocellar

space 0.30, eye length 0.30, eye width 0.21, eye height 0.30. Buccula elevated anteriorly, gradually narrowing posteriorly to mid eye level without abrupt change in width, extending beyond anterior of jugum for distance equaling about one-third length of scape; labium nearly attaining third abdominal segment, first segment not attaining thorax, second segment reaching posterior edge of fore coxae, third segment attaining mid level of hind coxae, segment lengths from base 0.64, 0.75, 0.90, 0.55. Antenna with scattered distally directed hairs on scape, (hairs sparse on pedicel, slightly more dense on third segment, dense on fourth), scape not attaining tip of tylus; segment lengths from base 0.26 (0.73, 0.70, 0.70).

Pronotum (with pubescence as on head), moderately punctate, distance between punctures 0.5 to 1.0× diameter of a puncture, impunctate along mid line, punctation more dense along callosities and along anterior portion of fascia; depressed across callosities, posterior lobe convex; lateral margins slightly swollen at callosities and straight between callosity and posterior angle; length 1.02, width 1.56. Scutellum (vestiture as on pronotum and head), punctation more dense, distance between punctures 0.5× or less the diameter of a puncture, each puncture also appearing slightly larger; Y-shaped carina distinct, arms moderately swollen, stem very low, outlined by punctation; length 0.76, width 0.91. Metapleuron swollen at callosity, distance between highest point of auricle to upper edge of evaporative area directly above approximately two-thirds the distance from auricle to callosity directly above, evoporative area on mesepimeron extending dorsally along intersegmental suture to level of callosity, evaporative area having about 26 distinct punctures, each with a single thin hair.

Hemelytron exceeding abdomen; corium and clavus clothed moderately with short, curved, appressed hairs, erect hairs lacking (costal margin with laterally projecting curved hairs on basal one-half becoming progressively shorter posteriorly); length of claval commissure 0.46, length of corium 2.32. Membrane with veins indistinct; basal length to level of corial apex 1.17, apical length from corial apex 0.94.

Abdomen with dense vestiture of very short, appressed hairs (and sparse vestiture of erect, slightly longer, posteriorly directed hairs); connexivum narrowly exposed laterally, spiracles obscure.

Color: Head ground color tawny to brownish-yellow, slightly darker around ocellus, slightly paler along mid line, near base of head and in margin around base of eye; buccula pale yellow, slightly darker on venter of head surrounding buccula from lorum to base of head and on lateral area of antenniferous tubercle from tip to eye, pale area below eye to darker venter. Scape pale brown apically, paler near base (remainder of antenna pale brown, darkest near joints).

Pronotum ground color brownish-yellow, callosities and punctures slightly darker causing impunctate median fascia to appear as a pale line; propleuron ground color and puncture color similar, pale reddish-brown area at base of acetabulum; prosternum slightly darker than ground color between and before acetabula anterior margin slightly paler. Mesopleuron pale yellowish-brown with posterior margin and acetabula more pale, darker brown ventrally; metapleuron pale yellowish-brown dorsally increasingly pale ventrally, very pale on dorsal margin, metapleural flange and acetabula. Scutellum pale yellowish-brown, more pale along mid line and along posterior one-third of sides.

Corium and clavus pale brownish-yellow, apex with irregular reddish-yellow markings; membrane hyaline.

Abdomen ground color pale brownish-yellow, slightly darker dorsally and an-

teriorly, few scattered reddish markings, ovipositor, in repose, very dark brown.

Legs pale yellow overall, femora with pale brown spots, some fused, apically tarsomeres slightly darker.

Size: Male, length 3.6-4.5, pronotum width 1.0-1.3; female, length 4.0-5.2; pronotum width 1.2-1.5.

Types: I have studied three specimens that are syntypes of *Nysius rubricatus*. All three have green labels with the name "Misiones" printed on them. The two female specimens have small rectangular labels bearing the word "Typus." The other specimen, a male, does not have a label indicating it is a type. Because Berg indicated in his original description that he had seen a male specimen and since the locality label on this specimen is identical to those on the female specimens, I assume the male is a syntype of *Nysius rubricatus*.

I have chosen the smaller of the two females as the lectotype. The specimen is mounted on a new point and the pin bears the following labels: a small white label with "♀," a small white label with a red border and the word "Typus" in red, and the green locality label with "Misio-/nes:" printed in black. The female paralectotype is also on a new point and the specimen bears the following labels: an identical green locality label, an identical "Typus" label, a small white label with "150" on the underside, a large white label with "Nysius rubricatus Berg" in Berg's handwriting and a smaller white label with "C.J. Drake/Coll. 1956" printed on it. The male paralectotype is mounted on an old, yellowed point, below this is a green locality label identical to those on the other specimens, and a white label with "C.J. Drake/Coll. 1956" as on the female paralectotype. These specimens are deposited in the Drake Collection at the U.S. National Museum of Natural History in Washington, D.C.

The lectotype is the most distinct individual in the type series and was selected because it is most likely to represent a species distinct from *N. jamaicensis* (Dallas). The *Nysius rubricatus* type differs from the Dallas type in being much paler, almost yellow, having an even paler impunctate fascia originating on the scutellum, crossing the pronotum, and ending on the posterior vertex, and having an elongate head and labium, the labium clearly exceeding the hind coxae. The third labial segment of the lectotype clearly longer than the head length before the ocelli. The third segment of the beak of *N. jamaicensis* is shorter than the preocellar head length. The paralectotypes are not so distinct in this character, with the third labial segment only slightly longer than the preocellar head length.

The problem lies in specimens which appear either to be ambiguous for crucial characters or to have intermediate characters. Some specimens of *N. rubricatus* have the dorsal fascia and short beak while other specimens have an indistinct fascia or a beak with the third segment equal in length to the head before the ocelli. There appears to be no correlation between the color, the fascia, and the beak length. The genitalia of these species seem identical, but the types represent such distinct conditions that I feel it is counterproductive to synonymize *N. rubricatus* at this time. When more information concerning the biology or cytology of this species is available, this problem may be solved.

Variation: As indicated above, none of the characters are as stable as one would wish. Most individuals have a mottled pattern, dark brown on a pale background, although other specimens are like the type, having an even light brown to light reddish-brown coloration. The very pale longitudinal fascia is usually evident on the pronotum and scutellum though occasion-

ally the fascia is not present or, at most, ill defined.

The size is quite variable although not unusually so for species of *Neortholomus*. The third segment of the labium may be only slightly longer than the anteocellar head length or it may be very clearly longer although not as long as in *N. koreshanus*.

Specimens examined: 41 males and 29 females.

Distribution: From Panama north of the Canal Zone south to central Peru (Huanuco, department), central Bolivia (Santa Cruz, department), and northern Argentina (Formosa and Misiones provinces) with scattered records from throughout Brazil (Amapa, Golias, Mato Grosso, Minas Gerais, Pernambuco, and Rio Grande do Sul, states). No records from Chile, Ecuador, French Guiana, Guyana, Uruguay, and Venezuela. Specimens have been found from coastal locations to elevations of approximately 1600 meters.

Food Plants: No data available.

Neortholomus koreshanus (Van Duzee)

Belonochilus koreshanus Van Duzee, 1909, 165-166.

Ortholomus koreshanus; Barber, 1947, 62; Slater, 1964, 337; Ashlock, 1967, 29, 34; Alayo, 1973, 22.

Neortholomus koreshanus is distinguished from other *Neortholomus* by the long head with small eyes, the very long beak which exceeds the mid level of the abdomen, and the pale, longitudinal fascia on the scutellum, pronotum, and posterior part of the vertex. The antenna is long but the scape does not exceed the very elongate tylus.

Neortholomus koreshanus specimens with slightly shorter beaks and correspondingly short heads look much like *N. rubricatus,* especially those *N. rubricatus* with longer than average beaks. Despite the similarity, the beak of *N. koreshanus* is always longer and the eyes are slightly smaller. There is no distributional overlap of these species.

Structure: Head elongate, especially tylus, vertex slightly convex between eyes and more strongly between ocelli, obscurely punctate; clothed densely with short appressed hairs and sparsely with short erect hairs about as long as an ocellar diameter; eyes moderate in size and appearing slightly stalked from head, highest point of eye slightly higher than head at base of eye, vertex distinctly higher; head length 1.21, width 0.99, anteocular length 0.70, interocular space 0.60, interocellar space 0.29, eye length 0.29, eye width 0.19, eye height 0.32. Buccula elevated anteriorly and gradually narrowing posteriorly to level of posterior eye margin without abrupt change in height, extending beyond anterior of jugum by one-half the length of scape; labium long, extending posteriorly to mid level of sixth abdominal segment, mid level of ovipositor, first segment attaining thorax, second segment of labium reaching anterior edge of middle coxae, third segment just reaching fourth abdominal segment, segment lengths from base 0.92, 0.92, 1.24, 0.85. Antenna with sparse vestiture of partially erect, distally directed, short hairs (more dense on fourth segment), scape not reaching tip of tylus, short by one-half its length, segment lengths from base 0.34, 0.70, 0.68 (0.66).

Pronotum with pubescence as on head, punctation moderate, distance between punctures from 0.5 to 1.0× diameter of a puncture, narrow median longitudinal fascia impunctate and slightly raised, pronotum moderately depressed at callosities, lateral margins moderately swollen at callosities, remaining margin to posterior angles slightly convex, length 1.02, width 1.41. Scutellum vestiture and punctation as on pronotum, Y-shaped carina evident but very low, stem of "Y" outlined by

punctures, arms not so distinct; length 0.66, width 0.71, metapleuron slightly swollen at callosity; distance from highest point of auricle to dorsal margin of evaporative area directly above greater than one-half distance from auricle to callosity directly above, evaporative area on mesepimeron and extending dorsally along intersegmental suture to level just above metapleural callosity, evaporative area with about 25 distinct punctures each with a thin hair.

Hemelytron exceeding abdomen; corium and clavus densely clothed with short appressed hairs and scattered erect hairs of same length, erect hairs projecting laterally along basal one-third of costal margin, becoming progressively shorter posteriorly; length of claval commissure 0.53, length of corium 2.21. Membrane with veins moderately distinct; basal length to level of corial apex 0.92, apical length from corial apex 1.21.

Abdomen densely clothed with short appressed hairs, moderate vestiture of short, erect, posteriorly directed hairs; connexivum narrowly exposed laterally, spiracles obscure.

Color: Head ground color yellow to yellowish-brown; dark reddish-brown about ocellus, anteriorly along lateral sides of carina to mid level of eye, and medially along carina as narrow band to anterior edge of eye; two parallel light brown lines at base of tylus, most pale about base of eye, on tylus, and between ocelli at base of head; very pale below eye from antenniferous tubercle to base of head; lorum brown, darker ventrally towards buccula, base of head around buccula brown, buccula pale yellow, dark brown spot behind eye next to thorax. Antenna yellowish-brown, more pale at joints, scape more pale basally.

Pronotum generally pale yellow, each puncture appearing slightly darker, callosities very dark reddish-brown with surrounding area slightly darker than ground color, propleuron colored as on dorsum, short band at base of acetabulum dark reddish-brown with surrounding area slightly darker than ground color, anterior edge of propleuron behind eye dark. Meso- and metapleuron yellow to yellowish-brown; acetabula, evaporative area, and posterior metapleural flange very pale; mesopleuron with short central longitudinal band, middle portion of anterior edge, and spot on dorsal one-half dark reddish-brown; metapleural callosity very dark reddish-brown. Scutellum light brown along anterior margin and becoming more yellow to pale yellow posteriorly, punctures slightly darker.

Corium and clavus very pale, claval commissure slightly darker, corial apex red to reddish-yellow; membrane very slightly milky, nearly hyaline, slightly infuscated centrally.

Venter of abdomen yellow to yellowish-brown, one brown spot dorsally on first three visible segments, some brown medially on first visible segment and on ventral one-third of first two intersegmental sutures.

Legs pale yellow, femora of all legs with light brown spots in no distinct pattern, some spots fused, near distal end spots fusing to form band, narrow basal band on tibia, last tarsomere dark brown.

Size: Male, length 4.6-5.4, pronotum width 1.2-1.4; female, length 5.3-5.9, pronotum width 1.3-1.6.

Type: Van Duzee's type series of *Belonochilus koreshanus* consists of two female specimens individually point mounted on a single pin. The upper white label reads "Estero, Fla My. 6-12. 08 Van Duzee," below is a white label reading "Co-type." A red U.S.N.M. label below this reads "Co.Type No. 12244 U.S.N.M." "Belonochilus Koreshanus V.D." is hand printed on a white label below all of the other labels. The upper specimen is here

designated as the lectotype of *Belonochilus koreshanus* Van Duzee, 1909. The specimens are in the U.S. National Museum of Natural History.

Variation: The lectotype and paralectotype are pale specimens, while the majority of the other specimens are much darker, especially in those areas on the type which are described above as dark. The pronotum, corium, and membrane may have dark brown markings and large portions of the venter of the head and abdomen may be dark brown to blackish-brown. Nevertheless, this species is generally paler than *N. scolopax, N. nevadensis,* or *N. arphnoides.*

Beak length varies from reaching the third abdominal segment to attaining the posterior edge of the sixth, or occasionally in small males it may reach the tip of the abdomen.

Specimens examined: 41 males and 49 females.

Distribution: Found throughout Florida from Pensacola and Jacksonville south to Key Largo. Also recorded from Isles of Pines but not from Cuba (Alayo, 1973) or any other Caribbean islands.

Food Plants: Only two plant associations have been made for this species. Van Duzee (1909), in the original description of *N. koreshanus,* reported finding it "abundant . . . in all stages of growth" on the seed heads of "a low branching hirsute labiate plant locally called 'pennyroyal.'" Needham (1948) referred to the plant as Florida Pennyroyal, *Pycnothymus rigidus.* He has recorded *N. koreshanus* as having been reared once from the seed head of *Bidens pilosa* (Compositae). This apparently is an uncommon occurrence since it was found in only one out of 1000 flower heads he had placed in jars. Blatchley (1926) reported taking "small numbers by beating water oak (*Quercus nigra* L.) and dead vines and sweeping vegetation near water." No clear association exists here. It appears likely that *Pycnothymus rigidus* is at least a preferred host.

Neortholomus nevadensis (Baker)

Ortholomus nevadensis Baker, 1906, 39; Slater, 1964, 337; Ashlock, 1967, 15, 34.

This large species is easily recognized by its stout rectangular form, very large substylate eyes, short head, and moderately elongate pubescence. The antennae are long with the scape exceeding the short tylus. The hemelytra are frequently slightly reduced, ending at or before the apex of the abdomen with only rare individuals having hemelytra of full length as in most of the other species. No other species of *Neortholomus* has this tendency towards brachyptery.

Although the size, color, and pubescence of *N. scolopax* are very similar to those of *N. nevadensis,* the two can easily be distinguished by head characters, *N. scolopax* having smaller eyes lying before the level of the ocelli.

Neortholomus nevadensis is extremely similar in appearance to the Old World *Ortholomus punctipennis* (Herrich-Schaefer). These two can be separated based on relative antennal segment lengths, the fourth antennal segments of *O. punctipennis* being slightly longer than the third segment while in *N. nevadensis* the third is longer than the fourth. Also, the membrane and corium of *O. punctipennis* tend to be opaque with a whitish tint and the evaporative area extends dorsally to near the metapleural callosity whereas in *N. nevadensis* the corium and membrane are translucent or hyaline and the evaporative area extends dorsally above the auricle less than one-half the distance to the callosity. The genitalic differences also distinguish the two genera.

Structure: Head nearly flat between eyes, slightly convex between ocelli, obscurely punctate, head clothed densely

with short appressed hairs and sparsely with erect hairs about twice as long as an ocellar diameter; eyes very large, spheroid, and substylate; highest point of eye higher than head at base of eye and level with vertex; head length 1.05, width 1.34, anteocular length 0.51, interocular space 0.77, interocellar space 0.39, eye length 0.32, eye width 0.27, eye height 0.41. Buccula elevated anteriorly then very gradually narrowing posteriorly to mid eye level and ending in abrupt curve to head, buccula extending beyond anterior of jugum by less than one-third length of scape; labium just attaining second abdominal segment, first segment just reaching prothorax; second segment reaching point midway between fore and middle coxae, third segment reaching point between middle and hind coxae, segment lengths from base 0.68, 0.65, 0.54, 0.48. Antenna with fine, erect, pale hairs sparse on scape, more on distal segments, most dense on fourth, scape exceeding tylus by about one-fourth its length; segment lengths from base 0.48, 1.02, 0.78, 0.71.

Pronotum with pubescence as on head, punctation moderate and irregular, distance between punctures from 0.5 to 1.0× diameter of a puncture; flattened between and only slightly depressed at callosities, posterior lobe slightly convex, lateral margins distinctly swollen at dorsal callosities, remaining margin slightly concave to posterior angle, length 1.00, width 1.55. Scutellum vestiture and punctation as on pronotum, Y-shaped carina evident, arms moderately swollen, stem of "Y" low and roughly outlined by punctures; length 0.63, width 0.85. Metapleuron swollen immediately below callosity; distance between highest point of auricle and upper edge of evaporative area directly above less than one-third distance from auricle to callosity directly above, evaporative area on mesepimeron and extending dorsally along intersegmental suture about one-half distance to dorsal edge of pleuron, evaporative area with ten distinct punctures each with a thin hair.

Hemelytron slightly shorter than abdomen; corium and clavus densely clothed with interspersed appressed and erect hairs, short hairs projecting laterally along basal one-third of costal margin becoming progressively shorter posteriorly; length of claval commissure 0.48, length of corium 2.06. Membrane with veins distinct; basal length to level of corial apex 0.87, apical length from corial apex (1.19).

Abdomen with moderately dense vestiture of short, appressed hairs interspersed with long, partially erect, posteriorly directed hairs; connexivum covered by hemelytra, spiracles obscure.

Color: Head ground color yellow to pale brown, two diverging dark brown bands on dorsum extending from base of head through ocelli to antenniferous tubercle and jugum, dark brown narrowly along tylus and posterior eye stalks; buccula pale yellow, dark brown at base of head between buccula and thorax, yellow below eye and antenniferous tubercle. Antenna dark brown basally becoming more pale distally.

Pronotum posteriorly with two dark brown bands to each side of midline, fusing anteriorly between callosities, these bands extending anteriorly to narrow pale anterior margin; pronotal callosities, narrow surrounding area, and lateral margin of pronotum very dark brown to black. Propleuron brown to dark brown except pale yellow acetabulum and triangular area below posterior angle of pronotum; prosternum pale yellow anterior to acetabula, darker between. Meso- and metapleuron dark brown except pale yellow acetabula and evaporative area. Scutellum brown, stem of Y-shaped carina pale.

Corium and clavus very light brown, corial apex slightly lighter, claval commis-

sure slightly darker; membrane hyaline without dark markings.

Venter of abdomen with wide, dark, reddish-brown band laterally, central area of segments II through V similarly colored, remainder mottled with yellow.

Legs brown with some yellow blotches, especially on femora; coxae basally brown and distally pale; trochanter pale; tibia brown basally and distally more pale; tarsi increasingly dark distally.

Size: Male, length 4.1-5.9, pronotum width 1.3-1.8; female, length 4.8-6.5, pronotum width 1.5-2.0.

Type: I have seen the presumed holotype and paratypes of *Ortholomus nevadensis* Baker through the courtesy of Dr. Guthrie of the Claremont Colleges. These specimens are syntypes since Baker (1906) did not indicate the selection of a holotype in the original description. Therefore, the designation of a lectotype is required.

A male specimen from Baker's collection is here chosen as the lectotype of *Ortholomus nevadensis* Baker. It bears the following labels, the uppermost first "Ormsby Co. Nev July. Baker," "441," "Nysius/n. sp." and "Ortholomus nevadensis Baker." The upper three labels are on white paper, the third one being folded, and the bottom label is red with a black border. The point mounted specimen was in the Baker Collection in the Joint Sciences Department at the Claremont Colleges, Claremont, California, recently transferred to the California Academy of Sciences, San Francisco.

All specimens of *N. nevadensis* with the original Baker label reading "Ormsby Co. Nev July. Baker" are considered paralectotypes. There are five such specimens (4 males, 1 female) in the Baker Collection at Claremont now in San Francisco, and four specimens have been seen in material from the Snow Entomological Museum, University of Kansas (1 male, 1 female), the U.S. National Museum of Natural History (1 male) and the California Insect Survey at the University of California at Berkeley (1 female).

Variation: The general color of *N. nevadensis* ranges from a dark gray with the color patterns being black and extensive, to a pale brown with the patterns brown and reduced. On pale specimens the femora are yellow with brown blotches, contrary to what occurs on the darker specimens like the lectotype.

Usually the hemelytra of *N. nevadensis* are slightly shorter than those of the other species of *Neortholomus,* having the tip of the abdomen even with or exceeding the membrane. Rarely, individuals have complete hemelytra with the membrane exceeding the apex of the abdomen by about one-fourth the membrane length.

Beak length varies moderately. The shortest beaks just reach the abdomen and the longest attain the third abdominal segment.

Specimens examined: 48 males and 55 females.

Distribution: Throughout California excluding the higher elevations of the Sierra Nevada with records from Arizona (Pinal County), Idaho (Gooding County), Nevada (Ormsby County), and Oregon (Jackson County).

Food Plants: I have seen only four with food plant data. Two were from oak (Fagaceae), another was from *Sisymbrium altissium* (Cruciferae), and the last was from *Ceanothus* (Rhamnaceae). Blatchley (1934) reported *N. nevadensis* from "wild sun-flower."

This is the least known of the four species of *Neortholomus* which occurs in the western United States. I have seen only six collections, including the types, from outside of California.

Neortholomus procerodorus, New Species

This species is distinguished from all

other species of *Neortholomus* by the elongate scent gland auricle. The antenna is short, similar to *N. arphnoides* except the scape exceeds the tylus by approximately one-fourth its length in the new species. The labium is very short, only reaching a point between the middle and hind coxae.

Neortholomus procerodorus is most likely to be confused with *jamaicensis* or *rubricatus*. The use of the auricle length as in the key, and examination of the genitalia will distinguish these species. The spermatheca of *N. procerodorus* has a stout basal sclerotized ring with a very reduced proximal flange, whereas *jamaicensis* and *rubricatus* have a longer and more slender basal ring without a flange. The aedeagus of the new species has a gonoporal process about half as long as the pigmented lobe and the clasper lacks a carina on the shank, while the aedeagus of *jamaicensis* and *rubricatus* has a gonoporal process about equal in length to the pigmented lobe and the shank of the clasper has a carina.

Structure: Head nearly flat between eyes and slightly convex between ocelli, obscurely punctate; head clothed densely with short, appressed hairs and moderately with long erect hairs about twice an ocellar diameter in length; eyes moderate sized, nearly hemispherical, and slightly stalked, highest point of eye above head at base of eye and about level with vertex; head length 0.87, width 1.05, anteocular length 0.41, interocular space 0.68, interocellar space 0.31, eye length 0.29, eye width 0.19, eye height 0.27. Buccula elevated anteriorly being wide to level before antenniferous tubercle then curving more sharply to head and gradually narrowing posteriorly to mid eye level. Buccula extending beyond anterior of jugum by less than one-fifth scape length; labium short, reaching midway between middle and hind coxae, first segment equaling buccula length, second segment reaching anterior edge of fore coxae, third segment attaining point between fore and middle coxae; segment lengths from base 0.43, 0.44, 0.43, 0.36. Antenna with short, fine, distally directed hairs being sparse to moderately dense on first three segments and more dense on fourth, antenna short, scape exceeding tylus by approximately one-fourth its length; segment lengths from base 0.34, 0.56, 0.48, 0.54.

Pronotum with pubescence as on head, erect hairs more vertical; punctation moderately dense, distance between punctures from 0.5 to 1.0× diameter of a puncture; pronotum depressed between callosities, central one-third of posterior lobe flattened, lateral one-third very slightly elevated, lateral margin of pronotum distinctly swollen at callosity, remaining margin slightly concave to posterior angle; length 0.87, width 1.41. Scutellum vestiture as on pronotum, punctation dense lateral to stem of Y-shaped carina, distance between punctures 0.5× or less a puncture diameter; Y-shaped carina evident, arms moderately swollen, stem of "Y" very low posteriorly and outlined by punctures; length 0.65, width 0.82. Metapleuron moderately swollen just below callosity, auricle elongate and narrow, distance from ventral tip of mesepimeron to dorsal edge of auricle two-thirds as long as from ventral tip of mesepimeron to metapleural callosity; evaporative area large, distance from dorsal edge of auricle to upper edge of evaporative area directly above about two-thirds distance from auricle to callosity directly above, evaporative area on mesepimeron and extending dorsally along intersegmental suture to dorsal edge of pleuron, evaporative area with about 20 distinct punctures, each with a short thin hair.

Hemelytron equal to or slightly exceeding length of abdomen; corium densely clothed with moderate length appressed hairs interspersed irregularly with some-

what erect hairs, basal one-third of costal margin with laterally projecting hairs becoming progressively shorter posteriorly; length of claval commissure 0.46, length of corium 1.94. Membrane with veins distinct; basal length to level of corial apex 0.80, apical length from corial apex 1.05.

Abdomen with dense vestiture of short appressed hairs interspersed sparsely with long, erect, posteriorly directed hairs; connexivum exposed lateral to corium, spiracles obscure.

Color: Head above generally pale yellowish-brown, tylus slightly paler except for two dark parallel lines at base, dark brown to black about ocelli, lateral to carina, around eye, and on venter; apex antenniferous tubercle pale yellowish-brown, narrow ring about eye and buccula pale. Antenna generally light brown, basal half pedicel more pale, distal half slightly darker.

Pronotum with two indistinct pale bands at elevated areas dividing posterior lobe longitudinally into three slightly darker sections, each section with irregular markings; anterior lobe pale reddish-brown to yellowish-brown, callosities black. Propleuron generally pale reddish-brown, acetabulum pale yellow; black area at base of acetabulum connecting with black lateral callosity forming black ring; prosternum black between acetabula, very pale along anterior margin. Meso- and metapleuron generally yellowish-brown; acetabula auricle, and posterior metapleural flange nearly white, orifice of auricle dark; wide longitudinal black band near center of mesopleuron, small black spot above this; metapleural callosity dark reddish-brown. Scutellum black longitudinally along central one-third and narrowly along anterior margin, lateral thirds red to reddish-brown and posterior tip pale.

Corium with anterior one-half pale with some light brown, irregular spots; clavus similar with anterior margin and claval commissure more brown, posterior one-half of corium generally brown and dark brown with obscure pale markings, corial apex red; membrane slightly milky, irregular brown markings between veins.

Venter of abdomen yellowish-brown, dark brown to black markings on ventral one-third of all segments, anterior three segments nearly all black ventrally, spots scattered on more posterior segments.

Femora pale yellow with rows of distinct brown spots, coxae and tibiae similarly pale, coxae brown basally, tibiae pale at joint followed by pale brown ring, pale central section, and a light brown distal one-third, tarsi light brown, dark distally.

Size: Holotype, male, length 4.3, pronotum width 1.4; paratype (same locality as holotype), male, length 4.3, pronotum width 1.4; paratype (Huancabamba), male, length 4.1, pronotum width 1.4; paratype (Panao), female, length 4.1, pronotum width 1.3.

Holotype: Male, Peru, Dept. Amazonas, vicinity of Chachapoyas, Andes, altitude 2000 m, 7 August 1936, F. Woytkowski collector, no. 3674, brook, in the Snow Entomological Museum, University of Kansas, Lawrence.

Paratypes: 1 male, same locality as holotype, 6 August 1936, no. 3673, boggy pond (genitalia dissected), in the Snow Entomological Museum. 1 female, Peru, Dept. Huanuco, Panao, altitude 8000 ft, 26 January 1947, J. C. Pallister collector (genitalia dissected), in the American Museum of Natural History, New York. 1 male, Peru, department unknown (see discussion below), Huancabamba, 13 August 1945, P. A. Berry collector, South American Parasitology Lab 1316-8, 46-4503 (genitalia dissected), in the U.S. National Museum of Natural History.

The exact collection site of the last mentioned male paratype is uncertain. There are two towns in Peru with the

name Huancabamba and although there are collection numbers on the specimen, I have been unable to find notes that go with these.

Variation: From the measurements given above, it can be seen that the four known individuals are extremely uniform in size and all have a distinct two-toned appearance. The head, pronotum, scutellum and posterior half of the corium are brown while the anterior portion of the corium and the membrane are whitish. These specimens show only slight variation in the color tone.

The length of the labium is very consistent. One of the specimens has very shallow and irregular punctures on the pronotum but this appears to be an abnormality.

Distribution: All of the specimens were collected at localities in the Andes Mountains of Peru. The type localities indicate that this may be a high altitude species. The holotype and one of the paratypes, collected by Felix Woytkowski, were both taken near water.

Etymology: *Procerus,* Latin, meaning long, and *odorus* meaning fragrant. A reference to the uniquely long scent gland auricle.

Neortholomus scolopax (Say)

Lygaeus scolopax Say, 1831, 775.
Nysius Saint-Cryi Provancher, 1872, 77.
Nysius (Ortholomus) longiceps Stål, 1874, 120.
Belonochilus ? scolopax; Stål, 1874, 122.
Nysius scolopax; Glover, 1876, 45, 55.
Orsillus scolopax; Gillette and Baker, 1895, 22.
Ortholomus uhleri Baker, 1906, 139.
Ortholomus longiceps var. *Cookii* Baker, 1906, 139. NEW SYNONYM.
Ortholomis (sic) *cookii;* Johnson and Ledig, 1918, 4.
Ortholomus scolopax; Barber, 1923, 714; Slater, 1964, 341-343; Ashlock, 1967, 34; Dailey, Graves, and Herring, 1978, 160.
Ortholomus scolopax cookii; Slater, 1964, 343.

Neortholomus scolopax can be difficult to recognize because of its variability in color and size. Although generally larger than *N. jamaicensis,* in the southern parts of its range, *N. scolopax* is about the same size. It can be separated from *N. jamaicensis* by its moderately reduced evaporative area and the greater density of erect hairs that give the head and pronotum a "fuzzy" appearance.

Neortholomus arphnoides is generally smaller than *N. scolopax,* but there is an overlap in sizes. It is easily separated from *N. scolopax* by the smaller sessile eyes, short antennae, convex vertex, and the larger evaporative area.

Overlap in size, color, and pubescence are found in sympatric populations of *N. nevadensis* and *N. scolopax.* In *N. nevadensis,* the eyes are larger and more stalked, and there is a tendency toward brachyptery. When the vertex of the head is viewed in a level position, and an imaginary line is drawn through the posterior margin of the eye facets, the ocelli of *N. nevadensis* will be on or anterior to the line while in *N. scolopax* the ocelli are posterior to it. The margin of the head posterior to the eye is perpendicular to the midline of the body in *N. nevadensis* and oblique to the midline in *N. scolopax* when the head is level.

The only other *Neortholomus* with a distribution overlapping that of *N. scolopax* is *N. koreshanus.* This Florida species has an evaporative area like *N. jamaicensis* and *N. arphnoides,* and the beak and head are extremely elongate.

Structure: Head moderately convex between eyes, more strongly at ocelli, obscurely punctate; clothed densely with short appressed hairs and moderately

densely with erect, longer hairs about twice as long as an ocellar diameter; eye moderately large, hemispherical, very slightly stalked from head, highest point of eye only slightly higher than head at base of eye, vertex clearly higher than eye; head length 1.02, width 1.07, anteocular length 0.51, interocular space 0.70, interocellar space 0.39, eye length 0.27, eye width 0.19, eye height 0.27. Buccula elevated anteriorly and gradually narrowing posteriorly, at level of anterior tip of antenniferous tubercle buccula narrowing more slowly and ending at mid eye level, extending beyond anterior of jugum by distance equaling one-fourth length of scape; labium reaching posteriorly to level of ventral trichobothria on third abdominal segment, first labial segment ending at mid eye level, second segment of labium just reaching mesosternum, third segment ending at hind coxae; segment lengths from base 0.58, 0.65, 0.68, 0.46. Antenna with erect distally directed hairs about as long as an ocellar diameter, moderately dense on basal three segments, more dense on fourth, scape about even with the tip of tylus; segment lengths from base 0.34, 0.70, 0.68, 0.75.

Pronotum pubescence as on head, erect hairs on anterior lobe slightly longer; punctation moderate and evenly distributed, distance between punctures about equal to diameter of a puncture; pronotum slightly depressed between callosities, anterior and posterior lobes equally convexed; lateral margins distinct, swollen at callosities, otherwise straight; length 1.02, width 1.43. Scutellum vestiture as on pronotum, punctation more dense, distance between punctures less than a puncture diameter; Y-shaped carina indistinct, arms low and broad, stem of "Y" very low, outlined by punctures; length 0.65, width 0.77. Metapleuron swollen at callosity; distance between highest point of auricle to upper edge of evaporative area directly above about one-third distance from auricle to callosity directly above, evaporative area on mesepimeron and extending dorsally along intersegmental suture almost to level of callosity, evaporative area with about 15 distinct punctures each with a thin hair.

Hemelytron about equal to length of abdomen; corium and clavus clothed densely with short appressed hairs interspersed with moderate vestiture of erect hairs slightly shorter than on pronotum, costal margin with laterally projecting hairs about as long as on dorsum on basal one-half, becoming progressively shorter posteriorly; length of claval commissure 0.43, length of corium 2.07. Membrane with veins indistinct; basal length to level of corial apex 0.88, apical length from corial apex 1.11.

Abdomen with dense vestiture of short appressed hairs interspersed with sparse to moderate vestiture of elongate, erect, posteriorly directed hairs; connexiva barely exposed lateral to corium, spiracles obscure.

Color: Head generally light reddish-brown to brown above, black behind ocelli to base of head, lateral to ocellus and on carina anterior to edge of eye, forming narrow band; short narrow black band along mesal edge of carina about equaling length of eye; yellow ring about base of eye dorsally, wider behind eye, and absent in front; venter of head with anterior two-thirds including antenniferous tubercle and lorum black; base of head immediately posterior to buccula black, buccula and gena below eye to base of head very pale. Antenna with scape and pedicel nearly totally black, pedicel slightly paler distally, fourth segment brown, but slightly darker basally, all segment joints pale in narrow band.

Pronotum ground color yellowish-brown, anterior lobe slightly more red, punctures brown, callosities black. Propleuron ground color as on notum, cal-

losity and narrow area at base of acetabulum black, acetabulum slightly lighter. Meso- and metapleuron light brown, wide longitudinal band just below middle of mesopleuron and callosity on metapleuron black, acetabula slightly paler. Scutellum brown, darker in punctures, stem of Y-shaped carina and posterior margin pale.

Corium and clavus very pale, corial apex red to reddish-brown, brown on claval commissure and irregularly on veins, membrane slightly milky with irregular brown markings centrally.

Abdomen brown, black markings on ventral one-third of basal segments, primarily second and third segments.

Legs light brown, coxae and trochanters slightly paler; femora spotted with large irregular markings, some spots fusing and forming band near distal end; tibia pale at joint, dark band following, and central area pale becoming darker distally; tarsi dark distally.

Size: Male, length 3.8-6.2, pronotum width 1.1-1.6; female, length 5.5-6.6, pronotum width 1.7-2.0.

As can readily be seen from the size data above, there is considerable size variation in *Neortholomus scolopax*. The smallest specimens of both sexes are from Mexico while the largest are from the U.S. In general, the more southern populations, especially those from southern Texas, Mexico, and Guatemala, are smaller than the population from more northern areas. To illustrate this trend I have measured two relatively long series from the northern and southern parts of the range. The series from the state of Oaxaca, Mexico (11 miles north of Matins Romero, 6 July 1971) consist of 20 specimens (11 male, 9 females) and the series from Dallas County, Iowa (September, 1924), contains 31 specimens (16 males, 15 females). Table 2 shows the measurements. This size trend may indicate a cline, but the data represent only two points in the widespread distribution of this species. Despite this fact, these data do reflect the size trend which I have observed.

Type: Both types of *Lygaeus scolopax* Say were destroyed by dermestids along with most of the Say Collection. Because this species is widespread and variable the male specimen described above has been selected as the neotype. It was collected between the 26th and 29th of September 1977 on the University of Kansas Rockefeller Tract, six miles northeast of Lawrence, Jefferson County, Kansas. It was collected on mature seed heads of *Pycnantheum tenuifolium*. This locality is approximately 150 miles south of Cedar Bluff, Iowa where one of Say's types was collected. The neotype is in the Snow Entomological Museum at the University of Kansas. The types of synonymous species are discussed below.

In agreement with Barber (1923) and Blatchley (1926), I consider *Nysius (Ortholomus) longiceps* Stål (1874) a synonym of *Lygaeus scolopax* Say 1831. I have seen specimens from the Swedish Museum of Natural History, Stockholm, through the kindness of Dr. Persson, which appear to be the types of Stål's *N. (O.) longiceps*. There is no label that indicates these are the types, nor is there any indication of this status at Stockholm according to Dr. Persson. Despite this lack of absolute identification as types of *N. longiceps*, the circumstantial evidence is strong. This series of 17 specimens follow a large label with the genus *Nysius*

TABLE 2. Size ranges for *N. scolopax* from extremes in distribution.

		Oaxaca, Mexico	Dallas Co., Iowa
Males	length	4.10-4.50	4.40-5.05
	width	1.18-1.35	1.33-1.53
Females	length	4.55-5.05	4.90-6.10
	width	1.40-1.55	1.40-1.70

written on it in Stål's handwriting. The series contains only specimens from all of the localities given by Stål in the original description of *N. longiceps*. Dr. Persson has been unable to locate any specimens in the collection at Stockholm that are designated as the types of *N. longiceps*. I feel that this series of specimens should be recognized as Stål's syntypic series and that designation of a lectotype is warranted.

A male specimen has been chosen from the above mentioned series as the lectotype of *Nysius (Ortholomus) longiceps* Stål 1874. This specimen has the following three labels, the topmost first: "Illinois" in Stål's handwriting on a small white label, "Belfrage." printed on a small white label and "Riksmuseum Stockholm" printed on a green label. In the remainder of the series, there are three specimens labeled like the lectotype, two are male *Neortholomus scolopax* and one is a male *Nysius;* three *N. scolopax* labeled "N. York," two females and one male; one female of *N. scolopax* labeled "N. Yersey."; one female of *N. scolopax* and three *Xyonysius californicus* labeled "Carolin. mer."; and one male and one female *N. scolopax* and three *Nysius* labeled "Wisconsin." All of these specimens are considered paralectotypes. The specimens from Illinois, New York, New Jersey and the *N. scolopax* from the Carolinas have a second label with "Belfrage" on it; and the Wisconsin specimen has a second label with "Kumlien." printed on it. All specimens have the green "Riksmuseum" label. These types are all in the Swedish Museum of Natural History (Naturhistoriska Riksmuseum), Stockholm, Sweden.

I have not seen the types of *Nysius saint-cryi* Provancher; Usinger (1941) saw the types which were collected from the Buffalo vicinity while visiting the Quebec Provincial Museum in 1937. He concluded that it is identical with *scolopax*.

Variation: This is a widely distributed species which is quite variable. The general body color ranges from pale browns with indistinct brown markings and brown callosities to dark grey with black markings and callosities. The variety *cookii* Baker 1906, for which I have seen the type, is based on a specimen with dark coloration. It is clear that this variety deserves no special recognition. The dark individuals occur throughout the U.S. and mixtures of pale and dark specimens can be found in single populations. The holotype is a single female from the mountains near Claremont, California with the name "Ortholomus Cookii Baker" on a red label. The specimen is in the Baker Collection at the California Academy of Sciences, San Francisco.

The length of the beak varies considerably; short beaks reach between the hind coxae, long ones attain the third abdominal segment. The size and shape of the dorsal pronotal callosites are also quite variable and have led to the description of a distinct species. *Ortholomus uhleri* Baker 1906 is based on a specimen with reduced oval pronotal callosities. I have seen other specimens with reduced callosities but this is the most extreme. I have carefully examined the holotype of *O. uhleri* and agree with Usinger's (1941) synonymy of this with *Neortholomus scolopax*. The type is a single male from Polk County, Wisconsin and is deposited in the Baker Collection at the California Academy of Sciences, San Francisco.

Specimens examined: 701 males and 845 females.

Distribution: Southern Canada, continental United States, Mexico and Guatemala.

Food plants: Plants in 13 families have been recorded as hosts. According to the label data, one of the primary plants on which *N. scolopax* occurs is *Oenothera* or specifically, *Oenothera biennis* (Onagra-

ceae). I have seen 28 males, 48 females, and three nymphs which were collected on *Oenothera*. This is over half of the 134 specimens with host plant associations. Judging from this it is likely that species of *Oenothera* are at least major hosts.

I have observed both adults and nymphs of *N. scolopax* on mature seed-heads of narrow-leaved mountain mint, *Pycnanthemum tenuifolium* Schrad. (Labiatae) at the University of Kansas Rockefeller Tract, Jefferson County, Kansas. They were feeding on the seeds and females were ovipositing in the seed-head next to the seeds. Smaller nymphs remain inside the seed-head. When aroused, adults and larger nymphs move under the seed-head and remain still, never falling to the ground. Several adults and nymphs were collected, brought to the laboratory and reared on the seed-heads. The time from egg to adult was observed to be about one month. The colony died out when the *Pycnantheum* seed was no longer available. Raw, hulled sunflower seeds were provided but apparently were not a suitable food.

Other plant associations in the following families have been recorded on specimens of *N. scolopax* (number of collections : number of specimens): Anacardiaceae (1 : 2), Compositae (3 : 16), Eriaceae (3 : 6), Labiatae other than *Pycnantheum* (2 : 3), Malvaceae (1 : 2), Polygonaceae (2 : 2), Polypodiaceae (1 : 7), Rosaceae (2 : 7), Scrophulariaceae (1 : 1), and Umbelliferae (1 : 1). Blatchley (1934) and Torre-Bueno (1946) reported *N. scolopax* as occurring on "sage-brush" (*Artemisia* ?, Compositae), Gillette and Baker (1895) reported it from *Glycyrrhiza lepidota* (Leguminosae), and Dailey et al. (1978) reported it on *Asclepias syriaca* (Asclepiadaceae).

It is quite likely that many plants may be hosts of *N. scolopax*, given its variability and distribution. Many of the other records are probably erroneous associations of transients or opportunists.

Neortholomus usingeri (Ashlock)

Ortholomus usingeri Ashlock, 1972, 91-93.

The very reduced evaporative area and the swollen spiracular openings on the broadly exposed connexivum readily distinguish *Neortholomus usingeri* from all other members of the genus. Also useful in recognition of this species are the small size, rectangular shape, the short antennae with the scape slightly exceeding the clypeus, the translucent whitish membrane with mottled infuscation, and short appressed golden pubescence.

The original description of this recently described species was used as the basic form for the descriptions in this paper. The structural description below is modified from the original description. The holotype was not seen during this study and additions to it were based on a paratype of similar size. The color description is quoted directly from Ashlock (1972) since there is considerable variation.

Structure: Head flattened between eyes (and slightly convex posterior to ocelli), obscurely punctate; clothed densely with flattened appressed hairs (and sparsely with short, erect hairs with length approximately equal to diameter of an ocellus); eyes prominent (hemispherical and substylate); head length 0.85, width 1.11, anteocular length 0.44, interocular space 0.61, interocellar space (0.24), eye length 0.22, eye width 0.29, eye height (0.34). Buccula widest anteriorly, gradually narrowing posteriorly to mid eye level without abrupt change in width (extending beyond anterior of jugum for distance about equal to one-fifth length of scape); labium reaching point behind hind coxae, first segment not attaining base of head (second segment attaining anterior edge of fore coxae, third segment nearly reaching

middle coxae); segment lengths from base 0.46, 0.43, 0.46, 0.39. Antenna with fine erect pubescence, first segment slightly exceeding tylus; segment lengths from base 0.29, 0.46, 0.44, 0.49.

Pronotum clothed with appressed flattened somewhat silky hairs, with occasional short erect hairs; moderately punctate, distance between punctures from 0.5 to 1.0× diameter of a puncture (distinctly depressed transversely at callosities, posterior lobe slightly convex, lateral margin slightly swollen at callosity); length 0.78, width 1.28. Scutellum with vestiture and punctation like those of pronotum, Y-shaped carina swollen on upper arms, stem not prominent; length 0.54, width 0.75. (Metapleuron swollen immediately below callosity, evaporative area reduced to narrow area about scent gland auricle, slightly extended dorsally along intersegmental suture at anterior edge of metapleuron and posterior edge of mesepimeron and mesopleuron, majority of mesepimeron without evaporative area, evaporative area with one or two distinct setal punctures.)

Hemelytron slightly exceeding abdomen; clavus and corium moderately clothed with short silky appressed hairs, lateral projecting short hairs along basal one-eighth of hemelytron (hair length about equal to ocellar diameter); veins evident but not prominent; length of claval commissure 0.49, length of corium 1.80. Membrane irregularly wrinkled transversely; veins distinct, basal length to level of corial apex 0.77, apical length from corial apex 0.78.

Abdomen with moderate vestiture of very short, appressed hairs and scattered, partially erect, posteriorly directed, short hairs; connexivum broadly exposed, spiracles raised and prominent.

"Color: Head very dark brown, clypeus, median stripe on posterior half of vertex, buccula, labium, and antenna paler except antennal segment IV very dark brown. Pronotum and scutellum reddish brown, callosities and punctures a little darker. Hemelytron pale yellowish brown, darkened apically on clavus and corium and on obscure spots on veins; vestiture nearly white, silky. Connexival segments pale, darker around pale spiracles. Legs yellowish brown, femur with obscure, slightly darker spots. Venter reddish brown, acetabula and scent gland paler." (Ashlock, 1972).

Size: Male, length 3.5-4.1, pronotum width 1.2-1.4; female, length 3.8-5.0, pronotum width 1.3-1.8.

Types: "HOLOTYPE. ♂, Santa Cruz Island, grassland, 1,800 ft., north of Academy Bay, 20 February, on *Hypericum pratense* (P.D. Ashlock)." (Ashlock, 1972). Paratypes. 96 males, 95 females, 4 nymphs collected on Santa Cruz and San Cristobal Islands in the Galapagos Archipelago. All of the types were collected in 1964 during the Galapagos International Scientific Project. The holotype is in the California Academy of Sciences, San Francisco, and the majority of the paratypes are in Peter D. Ashlock's personal collection, University of Kansas, Lawrence.

Variation: *Neortholomus usingeri* is relatively uniform in shape although the size varies considerably. The labium ends between the middle and hind coxae, the uniformity of this character being unusual in *Neortholomus*. The color is somewhat variable with a range from pale, uniformly colored specimens to the darker specimens with dark brown at the apices of the clavus and/or corium and on the pronotal callosities. Darker specimens also have scattered, slightly contrasting brown areas on the pronotum. There is also variation in the degree of mottling on, and the whiteness of, the membrane.

Specimens examined: 89 males, 94 females, 4 nymphs (paratypes); 2 males, 1 female, 7 nymphs (not types).

Distribution: Galapagos Archipelago; Santa Cruz, San Cristobal, Santa Maria and Pinzon islands.

Ashlock (1972) recorded specimens from *Hypericum pratense* (Hypericaceae), *Verbena* (Verbenaceae), and *Cordia* (Boraginaceae).

ACKNOWLEDGMENTS

I am grateful to Dr. Peter D. Ashlock who suggested this project and who has been an unending source of help through his personal library, the loan of specimens from his extensive orsilline collection, and his patient advice. I also wish to thank Dr. George W. Byers for his suggestions and advice and Marjorie Rothschild Hamilton for assistance in recording much of the label data from the nearly 5,000 specimens examined, and for proofreading of the manuscript. Thanks are also extended to Dr. Charles D. Michener of the University of Kansas, Dr. James A. Slater of the University of Connecticut, and Dr. John C. Morse of Clemson University for their suggestions concerning the manuscript. Thanks also to Jolene Walker for the typing of this manuscript.

My thanks go to the following individuals and institutions who helped in my research by generously allowing me to borrow specimens: P. H. Arnaud, Jr., California Academy of Sciences; H. Brailovsky A., Instituto de Biologia, Universidad Nacional Autónoma de Mexico; P. J. Clausen, University of Minnesota; W. R. Dolling, British Museum (Natural History), London; R. L. Fischer, Michigan State University; R. C. Froeschner, U.S. National Museum of Natural History; D. A. Guthrie, Claremont Colleges, California; W. J. Hanson, Utah State University; C. L. Hogue, Los Angeles County Museum of Natural History; J. D. Lattin and B. B. Frost, Oregon State University; T. E. Moore, University of Michigan; D. Otte, Academy of Natural Sciences of Philadelphia; L. L. Pechuman, Cornell University; P. I. Persson, Naturhistoriska Riksmuseet, Stockholm; J. A. Powell, University of California, Berkeley; G. H. Rosado Neto, Universidade Federal do Parana, Curitiba, Brasil; J. C. Schaffner and S. C. Merrit, Texas A & M University; R. T. Schuh, American Museum of Natural History; R. O. Schuster, University of California, Davis; J. A. Slater, University of Connecticut (personal collection); C. A. Triplehorn, Ohio State University; H. V. Weems and F. W. Mead, Florida State Collection of Arthropods, Gainesville; D. A. Young, North Carolina State University.

Finally, I would like to express my sincere appreciation to Virginia Ashlock whose critical editing of the Master's thesis, from which this paper is taken, has undoubtedly added to the clarity. I, of course, am responsible for any lack of clarity which remains.

LITERATURE CITED

ALAYO D. P. 1973. Los Hemipteros de Cuba, Parte XI, Familia Lygaeidae. Torreia, no. 25, 19 p.

ASHLOCK, P. D. 1957. An investigation of the taxonomic value of the phallus in the Lygaeidae (Hemiptera-Heteroptera). Ann. Entomol. Soc. Amer. 50:407-426.

———. 1967. A generic classification of the Orsillinae of the world (Hemiptera-Heteroptera: Lygaeidae). Univ. California Publ. Entomol. 48. 82 p.

———. 1972. The Lygaeidae of the Galapagos Islands (Hemiptera: Heteroptera). Proc. California Acad. Sci. 39:87-103.

BAKER, C. F. 1906. Notes on the *Nysius* and *Ortholomus* of America. Invert. Pac. 1:133-140.

BANKS, N. 1910. Catalogue of the Nearctic Hemiptera-Heteroptera. Amer. Entomol. Soc. Philadelphia, P. O. Stockhausen. 103 p.

BARBER, H. G. 1923. Family Lygaeidae, p. 708-737. *In* E. B. Britton (ed.), Guide to the Insects of Connecticut, Part IV: The Hemiptera or Sucking Insects of Connecticut. Bull. Connecticut Geol. Nat. Hist. Surv.

———. 1947. The family Lygaeidae (Hemiptera-Heteroptera) of the island of Cuba and the Isle of Pines. Mem. Soc. Cubana Hist. Nat. 19:55-75.

BERG, C. 1879. Hemiptera Enumeravit Specieque Novas. Pauli E. Conni, Bonariae. 316 p.

———. 1892. Nova Hemiptera faunarum Argentinae et Urugayensis, Lygaeidae. Ann. Sco. Cient. Argentina 33:151-165.

Blatchley, W. S. 1926. Heteroptera or true bugs of eastern North America, with special reference to the faunas of Indiana and Florida. Nature Publ. Co., Indianapolis. 1116 p.

———. 1934. Notes on a collection of Heteroptera taken in winter in the vicinity of Los Angeles, California. Trans. Amer. Entomol. Soc. 60:1-16.

Dailey, P. J., R. C. Graves, and J. L. Herring. 1978. Survey of Hemiptera collected on common milkweed, *Asclepias syriaca*, at one site in Ohio. Entomol. News 89:157-162.

Dallas, W. S. 1852. List of the Specimens of Hemipterous Insects in the Collection of the British Museum, Part II, p. 369-592. Taylor and Francis, Inc., London.

Distant, W. L. 1901. Rhynchotal notes, X: Heteroptera, Family Lygaeidae. Ann. Mag. Nat. Hist. 7:531-541.

Gillette, C. P., and C. F. Baker. 1895. A preliminary list of the Hemiptera of Colorado. Bull. Colorado Agr. Exp. Sta. 31:1-137.

Glover, T. 1876. Manuscript notes from my journal or illustrations of insects, native and foreign. Order Hemiptera, suborder Heteroptera or plant bugs. J. C. Entwisle, Washington, D.C. 132 p.

Hamilton, S. W. 1980. Revision of the New World Orsillini, with special reference to *Neortholomus*, n. gen. (Hemiptera-Heteroptera: Lygaeidae). Master's Thesis, Univ. Kansas, Lawrence, Kansas. 113 p.

Herrich-Schaeffer, G. H. W. 1838. Die Wanzenartigen Inseckten. C. H. Zeh'schen Buchhandlung: Nurnberg. 4:33-92.

Johnson, C., and R. Ledig. 1918. Tentative list of Hemiptera from the Claremont-Laguna region. J. Entomol. Zool. 10:3-8.

Kiritshenko, A. N. 1931. Bemerkungen uber einige Gattungen der Astacopinae. N. Beitr. syst. Insect. 5:16.

Munz, P. A., and D. D. Keck. 1959. A California Flora. Univ. California Press, Berkeley. 1681 p.

Needham, J. D. 1948. Ecological notes on the insect population of the flower heads of *Bidens pilosa*. Ecol. Monogr. 18:433-446.

Provancher, L. 1872. Description de plusieurs Hemiptères nouveaux. Nat. Canada 3:73-79.

Say, T. 1831. Descriptions of new species of heteropterous Hemiptera of North America. Reprinted 1859 *In* J. L. LeConte (ed.), The Complete Writings of Thomas Say on the Entomology of North America, Vol. 1, p. 310-368. Baillière Brothers, N.Y.

Slater, J. A. 1964. A Catalogue of the Lygaeidae of the World. Univ. of Connecticut, Storrs. 2 vols., 1688 p.

Stål, C. 1859. Hemiptera species novas descriptsis. Konglika Svenska Fregattens Eugenies resa omkring jorden, III: Zoologi, Insekter 1859:219-298.

———. 1872. Genera lygaeidarum Europae disposuit. Öfvers. VetenskAkad. Forh. Stockholm 29:37-62.

———. 1874. Enumeratio Hemipterorum, Part 4. K. Svenska VetenskAkad. Handl. 12:1-186.

Torre-Bueno, J. R. 1946. A synopsis of the Hemiptera-Heteroptera of America north of Mexico, III: Family XI, Lygaeidae. Entomol. Amer. 26:1-141.

Ueshima, N. 1979. Hemiptera, II: Heteroptera. *In* Animal Cytogenetics, 3, Insecta 6. Gebrüder Borntraeger, Berlin. 117 p.

Ueshima, N., and P. D. Ashlock. 1980. Cytotaxonomy of the Lygaeidae (Hemiptera-Heteroptera). Univ. Kansas Sci. Bull. 51:717-801.

Uhler, P. R. 1894. On the Hemiptera-Heteroptera of the island of Grenada, West Indies. Proc. Zool. Soc. London 1894:167-224.

Usinger, R. L. 1941. The present status and synonymy of some orsilline species (Hemiptera, Lygaeidae). Bull. Brooklyn Entomol. Soc. 36:129-132.

Van Duzee, E. P. 1907. Notes on Jamaican Hemiptera. Bull. Buffalo Soc. Nat. Sci. 5:1-79.

———. 1909. Observations on some Hemiptera taken in Florida in the spring of 1908. Bull. Buffalo Soc. Nat. Sci. 9:149-230.

———. 1914. A preliminary list of the Hemiptera of San Diego County, California. Trans. San Diego Soc. Nat. Hist. 2:1-57.

Wagner, E. 1958. Der *Nysius*-Komplex (Hemiptera-Heteroptera: Lygaeidae) in der Palaearktis. Comment. Biol. Helsing. 19:1-54.

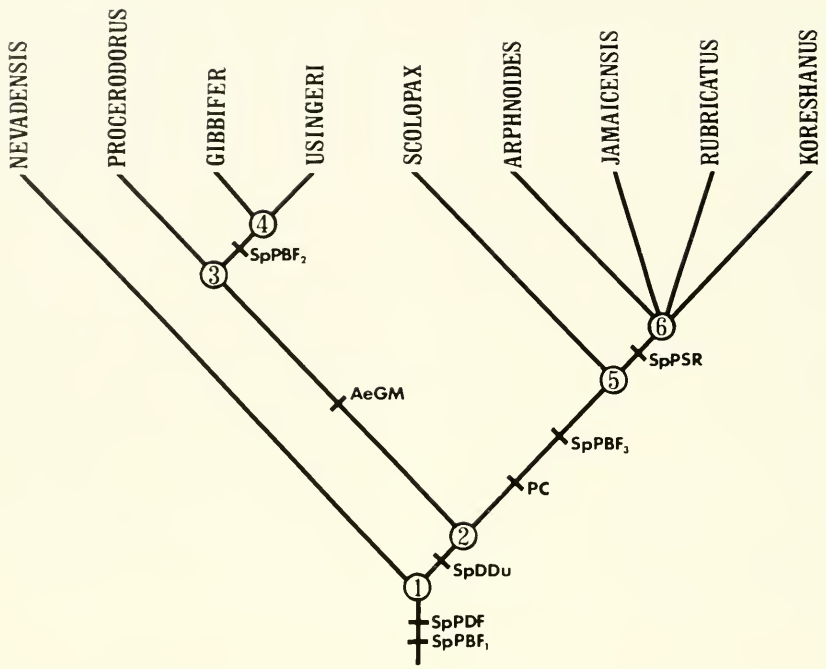


FIG. 1. Proposed phylogeny for *Neortholomus*. Character abbreviations explained in Table 1.

TABLE 1. Characters supporting the phylogeny of *Neortholomus* (Fig. 1).

Character abbreviation	Sex	Character	Apomorphous state	Reference* and Fig. #	Plesiomorphous state	Reference* and Fig. #
SpPDF	♀	Distal flange of sperm pump	absent	H—3	present	A—8a, c
$SpPBF_1$	♀	Basal flange of sperm pump	partially reduced	H—3c, d	complete	A—8a, c
$SpPBF_2$	♀	Basal flange of sperm pump	greatly reduced, present	H—3b	reduced ($SpPBF_1$)	H—3c, d
$SpPBF_3$	♀	Basal flange of sperm pump	completely lost	H—3a, e	reduced ($SpPBF_1$)	H—3c, d
SpDDu	♀	Distal duct of spermatheca	short	H—3a, b, d, e	long	A—8a, c H—3c
SpPSR	♀	Sclerotized basal ring of sperm pump	long and narrow	H—3e	short & stout	H—3a-d
PC	♂	Shank of paramere	with carina	H—4g, h	without carina	W—15 H—4a, e, f
AeGM	♂	Gonoporal process	well developed membrane	H—4c, j	little membrane	A—3a, 4a H—4b, d, i

* A = Ashlock (1967), H = this paper, W = Wagner (1958).

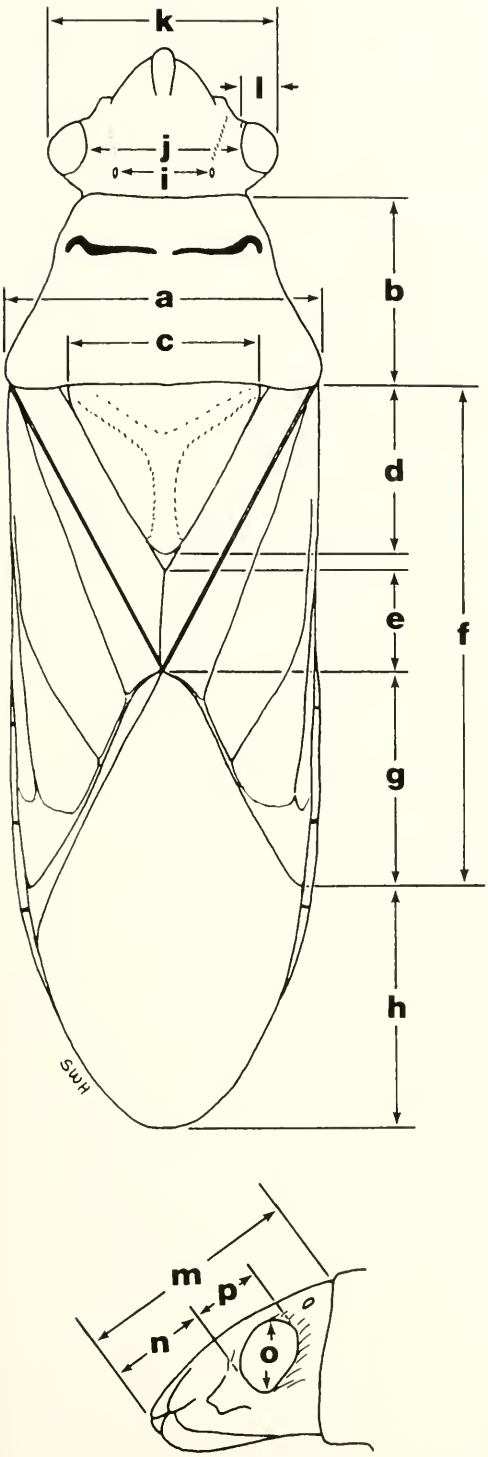


Fig. 2. *Neortholomus scolopax* (Say). a = pronotum width, b = pronotum length, c = scutellum width, d = scutellum length, e = claval commissure length, f = corium length, g = basal membrane length, h = apical membrane length, i = interocellar space, j = interocular space, k = head width, l = eye width, m = head length, n = anteocular head length, o = eye height, p = eye length.

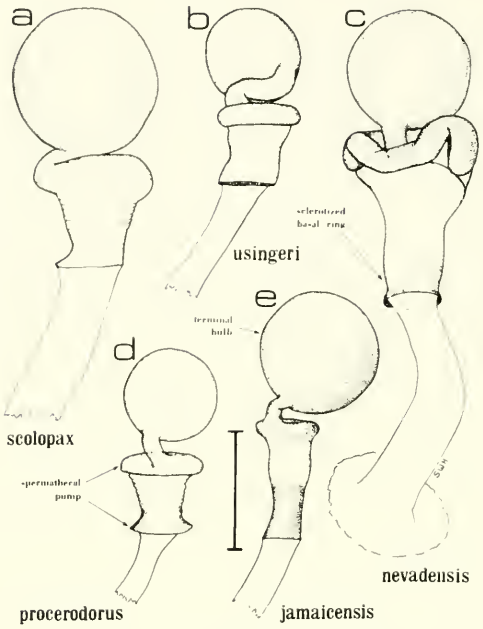


FIG. 3. Spermathecae of named species.
Scale = 0.15mm.

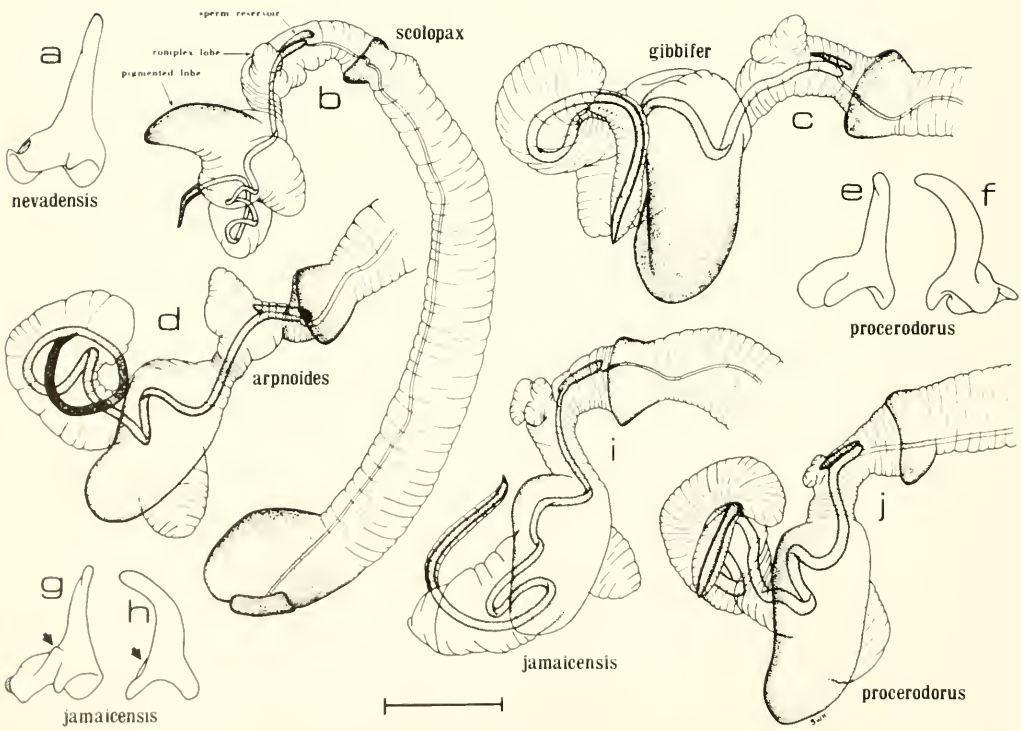


FIG. 4. a, e-h, parameres of named species; b-d, i, j, aedeagi of named species. Arrows on g and h indicate carina on shank of paramere. Scale = 0.15mm for a, e-j and 0.30mm for b.

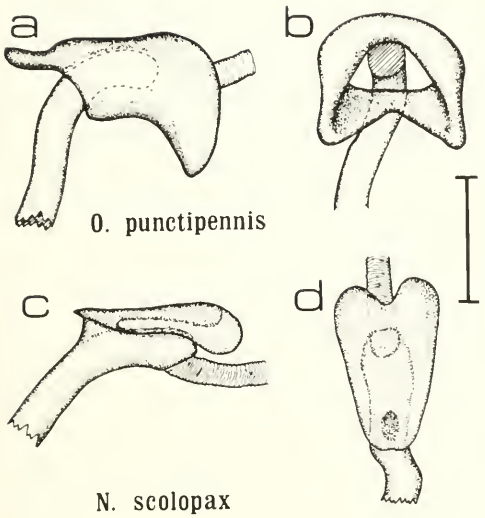


Fig. 5. Sperm reservoirs for named species. a, c, right lateral aspect; b, distal aspect; d, dorsal aspect. Scale = 0.016mm.

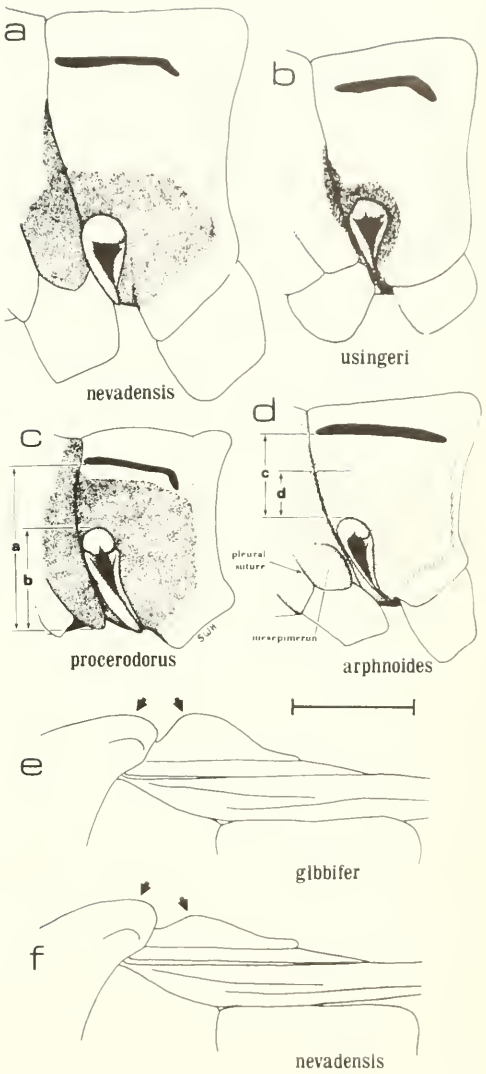


Fig. 6. a-d, meso- and meta- pleural areas of named species (dimensions: a/b = scent gland auricle length; c/d = evaporative area height). e-f, lateral aspect showing relative scutellum height (right arrow) to pronotum height (left arrow) of named species. Scale = 0.40mm for a-d.

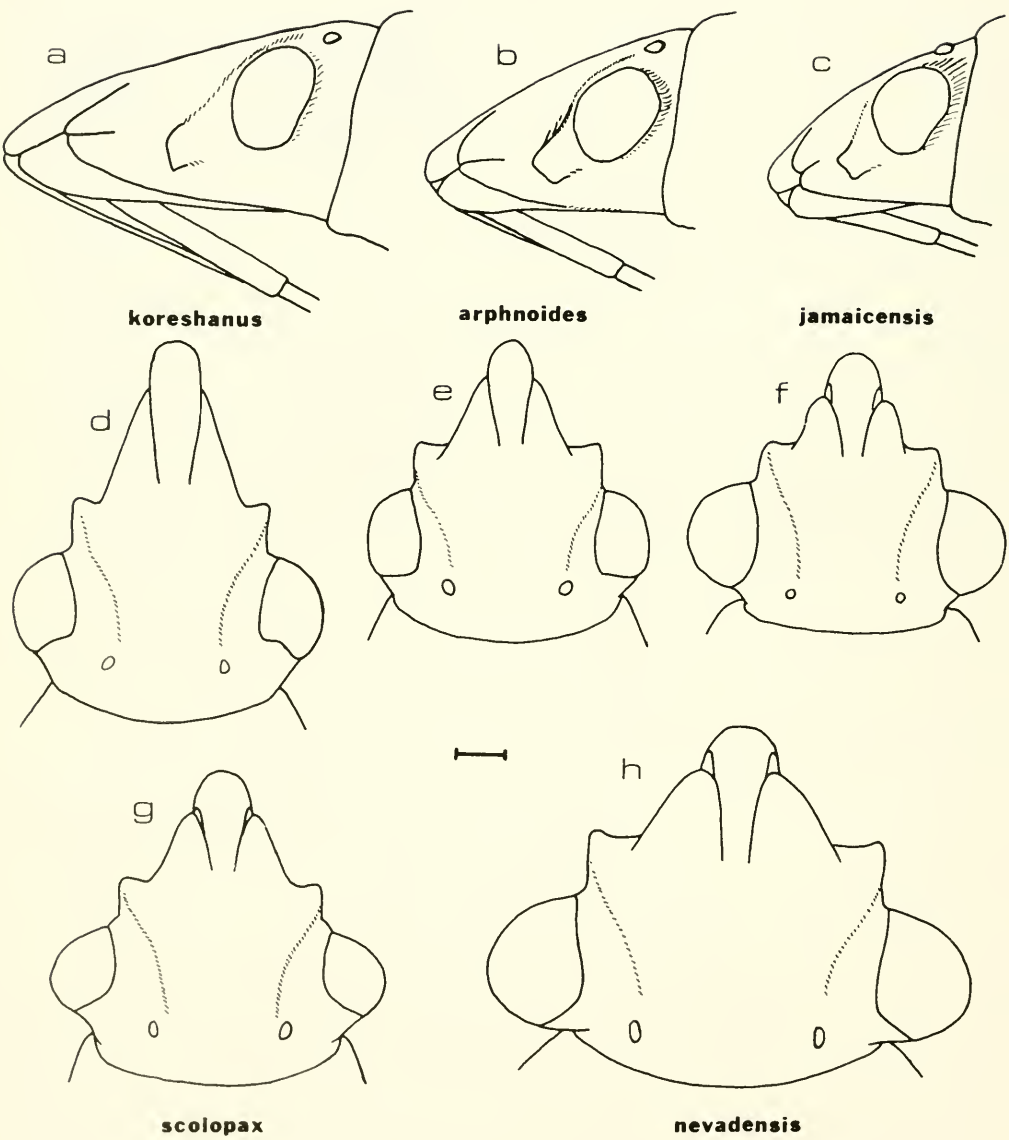


FIG. 7. a-c, head lateral aspects of named species; d-h, head dorsal aspects of named species. Scale = 0.11mm.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

LIBRARY
UNIVERSITY

REVISION OF THE BEE GENUS *LIPHANTHUS* (HYMENOPTERA: ANDRENIDAE)

By
Luisa Ruz and Haroldo Toro

Vol. 52, No. 8, pp. 235-299 December 23, 1983

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of individual papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Harvey Lillywhite
Charles D. Michener
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

Vol. 52, No. 8, pp. 235-299 December 23, 1983

Revision of the Bee Genus *Liphanthus* (Hymenoptera: Andrenidae)

Luisa Ruz*+ and Haroldo Toro*

Contents

Abstract . . . 237
Introduction . . . 237
Acknowledgments . . . 237
Materials and Methods . . . 238
Natural History . . . 239
Genus *Liphanthus* Reed . . . 240
Key to the species and subgenera . . . 241
Subgenus *Liphanthus* Reed, sensu stricto . . . 245
L. sabulosus Reed . . . 246
L. brevicornis n. sp. . . . 247
L. barbatus n. sp. . . . 251
L. chillanensis n. sp. . . . 252
Subgenus *Pseudoliphanthus* n. subgen. . . . 253
L. rozeni n. sp. . . . 254
L. spiniventris n. sp. . . . 255
L. andinus n. sp. . . . 257
L. unifasciatus n. sp. . . . 258
Subgenus *Xenoliphanthus* n. subgen. . . . 260
L. parvulus (Friese) . . . 260
L. tofensis n. sp. . . . 263
L. moldenkei n. sp. . . . 264
L. micheneri n. sp. . . . 265
Subgenus *Tricholiphanthus* n. subgen. . . . 267
L. leucostomus n. sp. . . . 268
L. pilifrons n. sp. . . . 268
L. tarsalis n. sp. . . . 270
Subgenus *Melaliphanthus* n. subgen. . . . 271
L. atratus n. sp. . . . 271
L. penai n. sp. . . . 272

+Department of Entomology, University of Kansas, Lawrence, Kansas 66045, U.S.A. and *Laboratorio de Zoología, Universidad Católica de Valparaíso, Av. Brasil 2950, Valparaíso, Chile.

Subgenus *Neoliphanthus* n. subgen. . . . 274
L. bicellularis n. sp. . . . 275
Subgenus *Leptophanthus* n. subgen. . . . 277
L. nitidus new name . . . 277
L. breviceps (Friese) . . . 280
L. anacanthus n. sp. . . . 280
L. australis n. sp. . . . 282
L. coquimbensis n. sp. . . . 283
L. cerdai n. sp. . . . 285
L. alicahue n. sp. . . . 287
Species Not Assigned to Subgenus . . . 289
L. friesellus n. sp. . . . 289
Phylogenetic Considerations . . . 290
Distribution . . . 296
Literature Cited . . . 299

Abstract

The genus *Liphanthus* is interpreted in a wider sense than that of Reed (1894) and subsequent authors. The following new subgenera, in addition to *Liphanthus sensu stricto,* are described: *Pseudoliphanthus, Xenoliphanthus, Tricholiphanthus, Melaliphanthus, Neoliphanthus,* and *Leptophanthus.* The subgenus *Liphanthus sensu stricto* includes: *L. sabulosus* Reed 1894, *L. brevicornis, L. barbatus,* and *L. chillanensis* n. spp.; subgenus *Pseudoliphanthus: L. rozeni, L. spiniventris, L. andinus,* and *L. unifasciatus* n. spp.; subgenus *Xenoliphanthus* includes: *L. parvulus* (Friese, 1916), *L. tofensis, L. moldenkei,* and *L. micheneri* n. spp.; subgenus *Tricholiphanthus: L. leucostomus, L. pilifrons,* and *L. tarsalis* n. spp.; subgenus *Melaliphanthus: L. atratus* and *L. penai* n. spp.; subgenus *Neoliphanthus: L. bicellularis* n. sp.; subgenus *Leptophanthus: L. nitidus* new name; *L. breviceps* (Friese, 1916), *L. anacanthus, L. australis, L. coquimbensis, L. cerdai,* and *L. alicahue* n. spp. For *L. friesellus* n. sp. no subgeneric status is given.

An analysis showing the probable cladistic relationships among the subgenera is also provided. All the species are described and illustrated.

Introduction

Liphanthus was originally proposed by Reed (1894) to include only *L. sabulosus.* Like other species of the genus, *L. sabulosus* presents such a remarkable sexual dimorphism that Reed could not associate the sexes; as a result he only described the male. The genus *Liphanthus* was recognized by Ashmead (1899) who correctly placed it among the Andrenidae and clearly differentiated it from the other genera of this family.

In 1908 Friese redescribed the male of *L. sabulosus* and considered *Liphanthus* as a synonym of *Psaenythia.* This placement was followed by Ducke (1912), Herbst (1921), Holmberg (1921) and Jaffuel and Pirión (1926). Again, Friese in 1916 described five more closely related species in *Psaenythia: P. rufiventris, P. parvula, P. pygmea, P. nigra,* and *P. breviceps;* these species are considered as *Liphanthus* in the present paper.

In 1922 Herbst recognized the sexual dimorphism in *L. sabulosus* and *L. parvulus* and placed *P. rufiventris* as a synonym of the former and *P. pygmaea* as a synonym of the latter. Four years later, Claude-Joseph (1926), in biological studies, confirmed Herbst's sex association for *L. sabulosus,* an association that was also indicated by Jaffuel and Pirión in the same year.

Contemporary to Friese's studies, Cockerell in 1916, following Reed's conceptions, considered *Liphanthus* as a clearly distinct genus. The genus was also considered distinct by Michener (1944), Rozen (1967, 1970) and Ehrenfeld and Rozen (1977).

The genus as here understood contains seven subgenera and 26 species. Since several of the species are known from very few specimens, it is nearly certain that more species exist.

Acknowledgments

We wish to express our profound thanks to the following persons: Dr. C. D. Michener of the University of Kansas for his useful suggestions and advice which contributed to the preparation of this paper and for the use of material in the Snow Entomological Museum, University of Kansas; Dr. F. Koch and the late Dr. E. Königsmann, both of the Museum für Naturkunde der Humboldt-Universität zu Berlin, for lending Friese's types; Padre J. S. Moure of the Universidade Federal do

Paraná (Curitiba, Brazil) for study specimens; Dr. R. J. McGinley of Harvard University for sending type material and specimens from the Reed collection; Dr. P. H. Arnaud of the California Academy of Science for study material; Dr. M. J. Viana of the Museo Nacional Bernardino Rivadavia (Buenos Aires, Argentina), Señor A. Camousseight of the Museo Nacional de Historia Natural de Santiago (Chile), Dr. Jorge Artigas of the Universidad de Concepción (Chile), and Dr. L. Campos of the Facultad de Agronomía de la Universidad de Chile (Santiago, Chile) for permitting study of the material from collections under their care; Professor J. Solervicens of the Universidad Valparaíso (Chile), Señor H. W. Sielfeld of the Museo de la Patagonia (Punta Arenas, Chile), and Dr. M. Cerda of the Ministerio de Salud (Santiago, Chile) for providing study specimens. Very special thanks to Dr. J. G. Rozen, Jr. of the American Museum of Natural History for his valuable suggestions and all the help that he provided for study in that museum.

Special thanks to Messrs. Jon K. Gelhaus and Robert W. Brooks of the Department of Entomology, University of Kansas for their help.

The drawings were made by Señor Enrique Peralta and the typing of the manuscript was by Mrs. Joetta Weaver.

This study was possible thanks to the financial aid of the American Museum of Natural History arranged through Dr. J. G. Rozen, the Universidad Católica de Valparaíso (Chile), and especially the National Science Foundation Grant DEB 77-23035 (C. D. Michener, principal investigator).

Materials and Methods

This paper is based on material from the collections whose curators are mentioned in the Acknowledgments above.

The descriptions of species and subgenera have been written with characters in the same sequence to facilitate comparisons. The term areolate in the key and descriptions is used as indicated by Harris (1979) for very minute reticulate patterns. The specific descriptions of females consider only the characters different from those mentioned in descriptions of males. Sexual characters of females such as antenna, similar in all species, are omitted (see generic characters). The prestigma and pterostigma are about the same color as nearby veins; in the descriptions only vein color is mentioned. The space between the mandibular socket and the transverse part of the hypostomal carina is called the postmandibular area.

The section on natural history is based primarily on previously published information. The data about geographical distribution have been obtained only from the material studied.

The measurements were taken with a Wild 5 stereoscopic microscope equipped with a 10× micrometer in the manner indicated by Michener (1965). The length of the propodeal triangle laterally is measured two thirds of the distance from the midline to the lateral extremity of the triangle and compared to the length of the metanotum measured at the same distance from the midline. The thickness of the clypeus (in side view) is measured from its tangent to its lateral extremity. The drawings were made using a camera lucida, comparable structures being drawn at about the same size regardless of differences in size of the bees.

The genitalia were cleared in KOH (10%) for 24 h (cold solution) or for 30 min at 70° C.

Most holotypes and allotypes have been deposited in the Toro collection, now at the Universidad Católica de Valparaíso, Chile. The paratypes will be broadly distributed in different collections as shown by the abbreviations at the end of each description. These abbreviations are as follows: **AMNH,** American Museum of Natural History, New York; **NMNH,** National Museum of Natural History, Washington, D.C.; **CAS,** California Academy of Sciences, San Francisco; **KU,** University of Kansas, Lawrence; **MCZ,** Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; **MIZT,** Museo ed Istituto di Zoologia Sistematica della Università di Torino, Italy; **BMNH,** British Museum (Natural History), London, England; **MNHUB,** Museum für Naturkunde der Humboldt-Universität zu Berlin, Germany; **MNHNP,** Musee National d'Histoire Naturelle de Paris, France; **MLP,** Museo de la Plata, Argentina; **MNBR,** Museo Nacional Bernardino Rivadavia, Buenos Aires, Argentina; **CONC,** Universidad de Concepción, Chile; **FAUCH,** Facultad de Agronomía de la Universidad de Chile, Santiago, Chile; **UCV,** Universidad Católica de Valparaíso, Chile; **HT,** Toro collection, Valparaíso, Chile.

Natural History

Little information about the natural history of *Liphanthus* exists. The available published data refer only to *L. sabulosus* and *L. parvulus.* Claude-Joseph (1926) indicates that *L. sabulosus* nests in clayey soil, describing briefly at the same time the shape and direction of the burrows and the egg location relative to the mass of food. Rozen (1967) notes that the linear disposition of the nest cells is unusual among the Panurginae.

Rozen (1970), studying the biology of *Kelita chilensis,* points out that this nomadine bee is a parasite of *L. parvulus* and describes in detail the placement of the parasite egg in the cell. Some years earlier, Friese (1916) had also suggested a similar association between *Kelita* and *L. sabulosus* (= *rufiventris*) but apparently without any proof of the association. Moreover, Ehrenfeld and Rozen (1977) indicate that a small undescribed species of *Liphanthus* here described as *L. alicahue* is probably associated with another nomadine bee, *Kelita tuberculata.*

Moldenke and Neff (1974) indicate that *L. sabulosus* and *L. parvulus* are associated with the following plants: *L. sabulosus: Chaetanthera incana, Pleurophora presilla, Chaetanthera* sp., *Adesmia* sp., *Hoffmannseggia falcaria;* and *L. parvulus: Adesmia arborea, Adesmia angustifolia, Adesmia* sp., *Calandrinia* sp., *Aristolochia* sp.

Personal observations are that certain species of *Liphanthus* visit the following plants: *L. parvulus: Oxalis* sp.; *L. chillanensis* n. sp.: *Oxalis* sp.; and *L. coquimbensis* n. sp.: *Gutierrezia taltalensis, Mesembrianthemum cristalinum, Baccharis paniculata.*

Biogeographic Considerations.—According to Moldenke (1976) *Liphanthus* is endemic to Chile. It is now known that it is primarily restricted to Chile. Its species range from Antofagasta to Chile Chico (between about 22° S and 46.5° S). It also extends, however, to Argentinean Patagonia from Chubut (40.3° S approx.) to Santa Cruz near Los Antiguos (47° S approx.) (Maps I and II). Two undescribed species are from Jujuy, Argentina.

In the scarce material available, little specific diversity has been observed in the arid zones of the north, but the number of species increases greatly in central and southern Chile.

The altitudinal distribution of the species is principally below 2,500 m, especially in areas of abundant vegetation. The distributions of the subgenera are considered after the cladistic analysis.

GENUS *LIPHANTHUS* REED

Small bees (3 to 7 mm long), nonmetallic black, sometimes with red metasoma; yellow areas conspicuous in males, sometimes greatly reduced in females; pilosity reduced, not forming metasomal hair bands; usually with three submarginal cells. *Coloration.* Head of male with yellow marks on mandibles, labrum (generally), clypeus, lower paraocular area (except in *Melaliphanthus*), and legs, sometimes forming one or two metasomal bands; marks reduced and more variable in female. *Pubescence.* Yellowish white, brown on last metasomal terga. Hairs, in general, short and sparse, mostly simple, with some briefly branched hairs mixed with simple ones. Distal margin of clypeus, at each side of midline, with two hairs so close to each other as to appear fused, and generally longer than the rest. Propodeal triangle laterally pubescent (scarcely hairy in *L. friesellus, unifasciatus,* and *atratus*). Metasomal terga with scarcely visible hairs; sterna with sparse hairs. *Integument.* Generally areolate, with some longitudinal striation on propodeal triangle (apparently absent in females of *L. nitidus* and *coquimbensis*). Punctation rather sparse and shallow, usually coarse on clypeus, absent on middle of basal area of propodeal triangle, fine and generally dense on metasomal terga but coarser on the last ones, absent on broad, usually depressed, marginal areas of terga, sparse on sterna and absent on very narrow smooth marginal areas. Labrum smooth proximally. *Structure.* Head somewhat broader than thorax. Epistomal suture below outer subantennal suture distinctly angulate, resulting angle of lower paraocular area smooth and usually swollen. Tentorial pit generally puncture-like in shape. Supraclypeal and interalveolar areas generally prominent. Flagellum longer than head in male, shorter than head and unmodified in female. First flagellar segment longer to much longer than broad in male, less than twice as long as second one in female. Facial fovea usually more distinct and longer in female than in male. Labrum in female less than twice as broad as long, with well marked transverse preapical carina, distal margin convex. Mandible without tooth (expanded on upper margin before apex in *L. rozeni* and *unifasciatus*). Glossa elongate. Maxillary palpus six-segmented, first three segments of similar length, last three progressively shorter. Labial palpus with four thin segments, first one about as long as rest of segments together. Hypoepimeral area trapezoidal. Scutellum about twice as long as metanotum. Marginal cell with truncation strongly slanting. Pterostigma narrow, slightly broader than prestigma, with sub-parallel sides, stigmal margin within marginal cell straight. Generally with three submarginal cells, one subgenus with two. Tibial spurs microserrate. Basitibial plate with marginal rim, somewhat widened distally and rounded in female, narrower at apex than base in male. Male with bifurcate claws. Second metasomal tergum proximally with strong transverse groove; lateral fovea elongate and well marked, wider and longer in female than in male. Pygidial plate well developed in female; in male, if present, without median longitudinal ridge. Metasomal sternum VII X-shaped, sheet-like lateral expansions small. Metasomal

sternum VIII longer than broad, arrowhead-shaped with rounded apex. Genital capsule without gonobase, gonocoxal apodeme narrow; gonocoxite rather elongate; gonostylus articulated, more than half of length of gonocoxite; penis valve usually reaching gonostylar apex; ventral basipenial plate rather broad, sclerotized, fused with penis at its base; volsella without special modifications.

Discussion: Liphanthus, among the Panurginae, could be close to: *Metapsaenythia, Protandrena, Pterosarus, Heterosarus,* and *Pseudopanurgus.* From *Metapsaenythia, Pterosarus, Heterosarus,* and *Pseudopanurgus* it usually is separated easily by having three submarginal cells. From the above genera including *Protandrena* it is differentiated by its narrow pterostigma and usually by its sparse punctation.

The recognition of *Liphanthus* is facilitated by the head which is broader than the thorax, and by the groove on the second metasomal tergum which differs from that of other terga.

Etymology: The derivation of the name *Liphanthus* is not explained in the original description. According to Dr. Michael H. Shaw, Professor of Classics at the University of Kansas, the word *Liphanthus* cannot be easily broken down into Greek elements. Dr. Robert L. Lind, also Professor of Classics (retired) at the University of Kansas, suggests that *Liphanthus* may have been derived from the Greek *leipo* which means lack and *anthos* which means flower. This is perhaps related to the fact that the males often fly in dried areas without flowers. Dr. George W. Byers of the Department of Entomology of the University of Kansas postulates that *Liphanthus* is an anagram of *Philanthus,* a genus of small sphecids of black and yellow color (as in *Liphanthus*). This explanation is strongly supported by the fact that Reed included *L. sabulosus* in Philanthidae.

Key to the Species and Subgenera

1. Males 2
   Females 27
2(1). Submarginal cells two (Fig. 108). Propodeal triangle laterally less than half length of metanotum (laterally). Subgen. *Neoliphanthus* . . . . . *L. bicellularis*
   Submarginal cells three (Figs. 5 and 53). Propodeal triangle laterally more than half length of metanotum (laterally) or almost same length 3
3(2). Hind tibial spurs with apices curved like claws, subequal in length (Fig. 56). Vertex concave or almost straight in frontal view. Subgen. *Xenoliphanthus* 4
   Hind tibial spurs with apices only slightly curved, inner somewhat longer than outer (Fig. 4). Vertex convex in frontal view . . . 7
4(3). Clypeus almost 4 times as broad as long, yellow without black spots 5
   Clypeus about 3 or little more than 3 times as broad as long, yellow with 2 basal black spots; if there are no spots, integument of mesonotum areolate and with homogeneous punctation 6
5(4). Hypoepimeral area scarcely punctate. Marginal cell very slightly longer than distance from apex to wing tip . . *L. parvulus*
   Hypoepimeral area densely punctate. Marginal cell conspicuously longer than distance from apex to wing tip . . . . . *L. tofensis*
6(4). Second metasomal sternum with 2 strong protuberances side by side in the middle. Head more than 1.5 times as broad as long; metasoma black. . *L. micheneri*
   Second metasomal sternum

without protuberances. Head less than 1.5 times as broad as long; metasoma reddish *L. moldenkei*

7(3). Distance between alveolus and inner orbit shorter than interalveolar distance or similar . . . 8
Distance between alveolus and inner orbit longer than interalveolar distance 16

8(7). Flagellar segment 1 about 3 times as long as broad. Clypeus flattened basally. Subgen. *Melaliphanthus* 9
Flagellar segment 1 less than twice as long as broad. Clypeus convex. Subgen. *Leptophanthus* . . 10

9(8). Sternum III with posterior margin projecting mesally. Facial fovea almost half as long as scape. Clypeus yellow on distal third . . . . . *L. atratus*
Sternum III with posterior margin almost straight. Facial fovea less than one-third as long as scape. Clypeus yellow only on distal margin . . . . . *L. penai*

10(8). Sternum II with projection broadly truncate apically, less than twice as long as broad (width measured at apex) 11
Sternum II with projection acute or slightly truncate apically, two or more times as long as broad (width measured at apex) 12

11(10). Sternum II with projection little longer than its apical width, posterior distal margin clearly sinuate lateral to projection (Fig. 117) . . . . . *L. breviceps*
Sternum II with projection not salient, distal margin scarcely sinuate lateral to projection (Fig. 123) . . . . . *L. anacanthus*

12(10). Labrum with transverse carina at distal fifth and distal pubescent band almost linear (Fig. 128 and 135) 13
Labrum with transverse carina at distal third and distal pubescent band wide (Figs. 110, 141, and 147) 14

13(12). Sternum II with posterior margins laterally gradually convergent toward projection. Sternum III with weak median protuberance (Fig. 129) . *L. australis*
Sternum II with posterior margin distinctly sinuate lateral to acuminate projection. Sternum III flat (Fig. 139) . . *L. coquimbensis*

14(12). Face above level of alveoli slightly areolate and shiny. Subantennal area generally black. . . . . *L. nitidus*
Face above level of alveoli strongly areolate and opaque. Subantennal area generally yellow 15

15(14). Flagellum distinctly longer than width of head; flagellar segments 9 and 10 distinctly longer than broad (Fig. 140). Mesonotum strongly areolate, with punctures sparse and weakly marked . . . . . *L. cerdai*
Flagellum scarcely longer than width of head; flagellar segments 9 and 10 almost as broad as long (Fig. 146). Mesonotum almost smooth between punctures, if areolate, always with well marked and dense punctures . . . . . *L. alicahue*

16(7). Metasomal sterna III and IV with posterior margins usually clearly concave (if slightly concave, with median, depressed, triangular, transparent area between apical thickenings). Subgen. *Tricholiphanthus* 17
Metasomal sterna III and IV with posterior margins convex or straight (without thickenings) . . 19

17(16). Pronotum with slightly protuberant dorsolateral angle. Pubescent margin of second ster-

nal projection as broad (side to side) as concavity on posterior margin of metasomal sternum III (Fig. 86) . . . . . *L. pilifrons*
Pronotum with distinctly protuberant dorsolateral angle. Pubescent margin of sternal projection narrower (side to side) than concavity on posterior margin of metasomal sternum III (Figs. 78 and 89) 18

18(17). Hind basitarsus with base broader than apex, second tarsal segment somewhat longer than broad . . . . . *L. tarsalis*
Hind basitarsus parallel-sided, second tarsal segment twice as long as broad. . . . . *L. leucostomus*

19(16). Clypeus, in side view, concave basally and thickness (due to great protuberance) greater than length (Fig. 153) . . *L. friesellus*
Clypeus, in side view, convex basally and thickness similar or smaller than length (Fig. 2) . . . 20

20(19). Pygidial plate present. Head in ventral view with lateroventral area of clypeus widened mesally (Fig. 3). Frontal line in a very long and well marked groove. Subgen. *Liphanthus*. . . . 21
Pygidial plate absent. Head in ventral view with lateroventral area of clypeus widened laterally (Fig. 45). Frontal line scarcely marked, not in groove. Subgen. *Pseudoliphanthus* 24

21(20). Flagellum gradually enlarged distally. Laterodistal margin of clypeus in frontal view strongly concave (Fig. 16) and with long hairs . . . . . *L. barbatus*
Flagellum not enlarged distally. Laterodistal margin of clypeus almost straight (Fig. 1), with short hairs only 22

22(21). Flagellum longer than head; flagellar segments longer than broad, last one about two and a half times as long as broad (Fig. 11) . . . . . *L. brevicornis*
Flagellum generally distinctly longer than head; flagellar segments about twice as long as broad or more, last one three or more times as long as broad . . . 23

23(22). Last flagellar segment distally about half as broad as median segments, strongly curved (Fig. 1). Scape with yellow spot . . . . . *L. sabulosus*
Last flagellar segment about as broad as median segments, almost straight (Fig. 21). Scape without yellow spot . . *L. chillanensis*

24(20). Metasomal sternum II without postero-median projection. Outer subantennal suture slightly arcuate laterally. Metasoma with one yellow transverse band . . . . . *L. unifasciatus*
Metasomal sternum II with postero-median projection. Outer subantennal suture strongly arcuate laterally. Metasoma with 2 yellow transverse bands 25

25(24). Projection of sternum II acute (Fig. 35). Flagellum longer than head width . . . . *L. spiniventris*
Projection of sternum II truncate (Figs. 40 and 30). Flagellum as long as head width or less 26

26(25). Metasomal sternum III with postero-median protuberance. Posterior margin of sternum II with median projection much broader than long (Fig. 30). Mandible with preapical widened plate (similar as in Fig. 154). . . . . *L. rozeni*
Metasomal sternum III unmodified. Posterior margin of sternum II with median projection about as long as apical width (Fig. 40). Mandible not widened preapically . . . . . *L. andinus*

27(1). Submarginal cells two. Propodeal triangle laterally about half length of metanotum (laterally). Subgen. *Neoliphanthus* . . . . . *L. bicellularis*
Submarginal cells three. Propodeal triangle laterally slightly more than half length of metanotum (laterally) or almost same length 28

28(27). Hind tibial spurs with apices curved like claws, subequal in length (Fig. 56). Vertex concave or almost straight in frontal view. Subgen. *Xenoliphanthus* . . . 29
Hind tibial spurs with apices slightly curved, inner somewhat longer than outer (Fig. 4). Vertex convex in frontal view 32

29(28). Claws apparently simple. Clypeus almost 4 times as broad as long. 30
Claws bifurcate. Clypeus scarcely more than 3 times as broad as long 31

30(29). Hypoepimeral area almost smooth. Marginal cell scarcely longer than distance from apex to wing tip . . . . . *L. parvulus*
Hypoepimeral area densely punctate. Marginal cell clearly longer than distance from apex to wing tip. . . . . *L. tofensis*

31(29). Mesonotal integument distinctly areolate. Metasoma black . . . . . *L. micheneri*
Mesonotal integument almost smooth. Metasoma red *L. moldenkei*

32(28). Lateral ocelli, in frontal view, above upper orbital tangent. Inner orbits divergent dorsally. Subgen. *Leptophanthus* . . . 33
Lateral ocelli, in frontal view, at same level or slightly below upper orbital tangent. Inner orbits convergent dorsally or almost subparallel 37

33(32). Integument above alveoli smooth and shiny. Pronotal lobe black 34
Integument above alveoli strongly areolate and dull. Pronotal lobe generally with distal yellow spot 35

34(33). Base of mid tibia with yellow spot about as long as last flagellar segment. Clypeus generally black . . . . . *L. coquimbensis*
Base of mid tibia with yellow spot much shorter than last flagellar segment. Clypeus generally with distal yellow spot . . . . . *L. nitidus*

35(33). Mesonotum areolate, scarcely punctate. Clypeus generally with small yellow spot distally. Length about 4 mm . *L. cerdai*
Mesonotum almost smooth between punctures, punctation moderately dense. Clypeus black or with longitudinal yellow band. Length about 5 mm or more. 36

36(35). Facial fovea somewhat shorter than scape. Clypeus with longitudinal yellow band *L. alicahue*
Facial fovea longer than scape. Clypeus black. . . . . *L. anacanthus*

37(32). Outer subantennal suture almost straight (Figs. 90 and 96). Clypeus, inferior paraocular area and base of mandible without yellow. Subgen. *Melaliphanthus* 38
Outer subantennal suture distinctly arcuate laterally (Figs. 1 and 26). At least clypeus with yellow 39

38(37). Frontal line, in lower half, hardly visible. Propodeal triangle sparsely striate. Tibial scopa less dense than hairs of fore femur . . . . . *L. penai*
Frontal line, in lower half, a narrow groove. Propodeal triangle densely striate. Tibial scopa

dense, similar to hairs of fore femur . . . . . *L. atratus*

39(37). Frontal line almost imperceptible. Lower paraocular area and tegula without yellow. Subgen. *Pseudoliphanthus* 40
Frontal line distinct, in a groove. Lower paraocular area and tegula with yellow. Subgen. *Liphanthus* 41

40(39). Clypeus (central area) depressed distally, more than 3 times as broad as long. Subantennal area and basal half of mandible yellow. Metasomal terga yellowish . . . . . *L. rozeni*
Clypeus slightly convex, less than 3 times as broad as long. Subantennal area black. Mandible mostly dark mahogany. Metasomal terga black . . . . *L. andinus*

41(39). Marginal cell generally longer (or similar in length) than distance from apex to wing tip. Second submarginal cell with anterior margin about as long as posterior or somewhat shorter. Paraocular spot extending ventrally to level of tentorial pit or slightly below it . . . . . *L. sabulosus*
Marginal cell usually shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Paraocular spot generally extending ventrally farther below level of tentorial pit 42

42(41). Integument of thorax almost smooth. Facial fovea sinuous, widened ventrally . . . . . *L. brevicornis*
Integument on thorax strongly areolate. Facial fovea almost straight, not widened ventrally 43

43(42). Facial fovea subparallel to inner orbit. Clypeus 3 times as broad as long. Outer surface of mid basitarsus with small basal yellow spot . . . . . *L. barbatus*
Facial fovea ventrally farther from inner orbit than dorsally. Clypeus less than 3 times as broad as long. Outer surface of mid basitarsus with large yellow area extending beyond middle . . . . . *L. chillanensis*

Subgenus *Liphanthus* Reed, sensu stricto
Figs. 1-25

Liphanthus Reed, 1894: 645.
Type species: *Liphanthus sabulosus* Reed, 1894 (monobasic).

Both sexes: Vertex convex. Lateral ocelli at same level as or below upper orbital tangent. Interalveolar area prominent. Supraclypeal area convex. Frontal line in a groove above alveoli. Clypeus convex, lateral area transversely elongate, sloping upward toward central area, widened mesally in ventral view. Inner orbits almost straight medially, divergent below. Distance between alveoli less than distance from alveolus to inner orbit and longer than alveolus diameter. Outer subantennal suture arcuate laterally (Fig. 1). Pronotum without protuberant dorsolateral angle. Submarginal cells three. Propodeal triangle laterally more than half length of metanotum (laterally). Tibial spurs yellow or pale testaceous. Hind tibial spurs with apices slightly curved, inner slightly longer than outer.

Male: Head and legs with yellow marks, metasoma with two yellow transverse bands. Lateral area of clypeus with hairs sparse (dense in *L. barbatus*) and shorter than clypeal length. Flagellum generally much longer than head; first flagellar segment approximately three times as long as broad. Facial fovea short, clearly separated

from inner orbit, half as long as scape or less. Middle of paraocular area with transverse swelling below facial fovea; lower part of paraocular area rather flat. Postmandibular area mesally much less than half as long as width of base of mandible. Sterna unmodified. Pygidial plate present.

Female: Lower paraocular area and tegula each with yellow spot. Tibial scopa somewhat dense, similar to or less dense than hairs of fore femur. Third flagellar segment broader than long.

Liphanthus (Liphanthus) sabulosus Reed
Figs. 1-10; Map I, A

Liphanthus sabulosus Reed, 1894: 646, 652; Cockerell, 1916: 428; Rozen, 1967: 5, 9; Rozen, 1970: 147; Ehrenfeld and Rozen, 1977: 3.

Psaenythia sabulosa, Friese, 1908: 32, 39; Herbst, 1922: 183; Jaffuel and Pirión, 1926: 369; Claude-Joseph, 1926: 213.

Psaenythia rufiventris Friese, 1916: 166, 169.

Male: Length about 6 m, forewing length 4 mm, head width 2.5 mm, thoracic width 2 mm. *Coloration.* Head and thorax black, the following parts yellow: face below median ocellus and facial fovea, labrum, mandible (apex mahogany), under side of scape (upper surface brown), flagellum (sometimes brown apically and with upper surface or segmental spots brown), pronotal lobe, small spot on tegula, distal margins and under surfaces (variable) of trochanters, ventral edges and apices of fore and middle femora, apex of hind femur, tibiae and tarsi (except middle distitarsus and small segments of hind tarsus which are light brown). Wings almost hyaline; veins and tegula testaceous. Metasomal terga black, terga I and II each with transverse yellow band (wider on II). Metasomal sterna brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral areas of clypeus scarcely pubescent, with hairs shorter than those of labrum. *Integument and Punctation.* Head and thorax lightly to strongly but finely areolate and shiny, smooth on gena and yellow parts of face, with some striation on propodeal triangle. Facial punctation weak and sparse, deeper and denser in orbito-ocellar area (strongly marked in other specimens) and dorsal half of gena, and coarsest on lower central part of clypeus. Dorsal part of thorax finely punctate, sparsely so on discal scutal area, punctures fine and sparse on hypoepimeral area, denser and deeper on rest of mesepisternum. *Structure.* Head approximately 1.5 (rarely 1.3) times as broad as long. Flagellar segments much longer than broad, last one more slender than others, three or more times as long as broad and distinctly curved. Facial fovea about one-third as long as scape, oval, generally narrower near dorsal end. Inner subantennal suture with upper part strongly angulate toward mid-line of face (almost straight in some specimens) and shorter than width of subantennal area. Clypeus about 4 times as broad as long, projecting beyond lower orbital tangent for about one-third of its length, with longitudinal protuberance. Labrum flat, about twice as broad as long or less, distal margin slightly convex. Mandible unmodified. Marginal cell about as long as distance from apex to wing tip. Second submarginal cell with anterior margin about as long as posterior or somewhat shorter. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 7 mm, forewing length 4.5 mm, head width 2.5 mm, thoracic width 2 mm. *Coloration.*

Head and thorax black, antennal flagellum light mahogany beneath, the following parts yellow: area lateral to outer subantennal suture extending down to tentorial pit or slightly below it, subantennal area, T-shaped spot on upper part of clypeus, base of mandible (apex mahogany), pronotal lobe, small spots on apices of fore and mid femora and bases of fore and mid tibiae (tarsi dark brown). Wings and tegula as described for male but somewhat darker. Metasoma red (somewhat darker in some specimens) except base of segment I, lateral fovea on tergum II, margin of tergum V and pygidial plate which are black (the last sometimes dark mahogany). *Pubescence.* As described for male but denser and longer on head, mesepisternum and legs; tibial scopa somewhat densely hairy, but less dense than hair of fore femur. *Integument and Punctation.* Head and thorax lightly, finely (sometimes more strongly) areolate, smooth on lower parts of face and gena. Densely and coarsely punctate on head, sparser and coarser on clypeus, finer and denser above antennal sockets and on genal area. Thorax with medium-sized punctures, sparse in discal part of scutum, deeper and sparse on scutellum, dense on mesepisternum. Pygidial plate slightly areolate. *Structures.* As described for male except: facial fovea shorter than scape and slightly sinuate (almost straight in some specimens). Clypeus approximately 3 times as broad as long, with weak longitudinal elevation on upper half. Lower part of frontal line carinate, apex minutely grooved. Marginal cell generally longer than (or equal to) distance from its apex to wing tip. Second submarginal cell with anterior margin somewhat shorter than posterior. Pygidial plate almost flat apically.

The specimens, especially males, show wide variability in some characters, such as size, sculpturing (from smooth to areolate) and curvature of the subantennal suture. Color variations also exist, from yellow to brown on the labrum, different spot sizes on the legs, and sporadic presence of a yellow spot on gena.

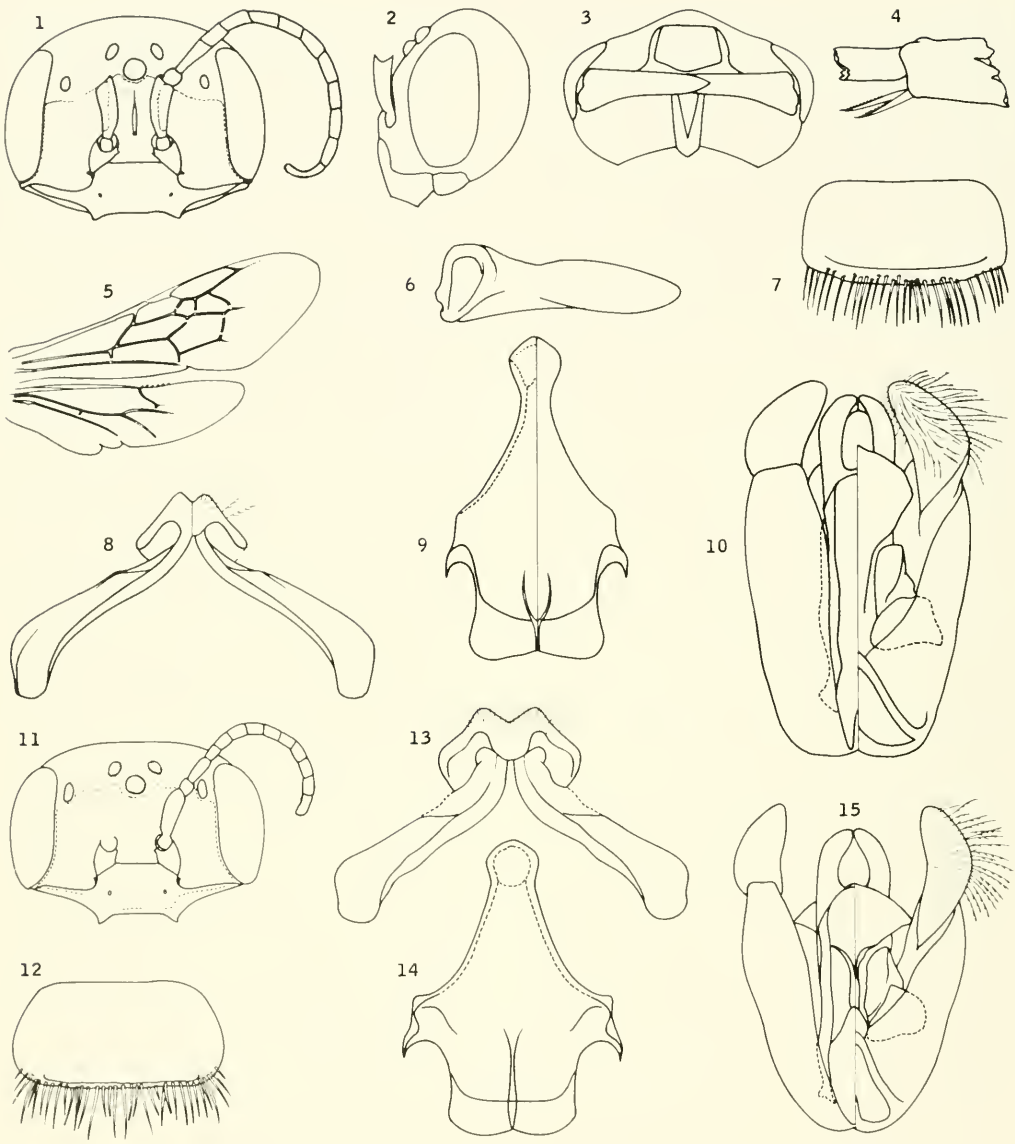
Material Studied (all from Chile): 7 males and 2 females, Coquimbo Prov., diverse localities, from October to January; 2 males and 5 females, Aconcagua Prov., January and February; 87 males and 22 females (2 more without data), Valparaíso Prov., diverse localities, October to February; 28 males and 5 females, Santiago Prov., diverse localities, December to January. Altitudes range from sea level to at least 2200 m.

Among the specimens collected by P. Herbst, 2 males labeled as Type were found in the Museum of Comparative Zoology, Harvard University. One of them (with broken head) has a label that indicates it was collected in Valparaíso in 1900. The other is headless, with an additional red label which reads "Type coll. Edw. C. Reed," but no date, locality or collector name is provided. The latter specimen (unfortunately headless) is the only known syntype, and is here designated as lectotype and has been so labeled.

Liphanthus (Liphanthus) brevicornis new species

Figs. 11-15; Map I, B

Diagnosis: Similar to *L. sabulosus* but male with flagellum not distinctly longer than head, last flagellar segment as broad as median segments and about 2½ times as long as broad, fore and mid femora sometimes with short yellow spot on ventral edge; female with marginal cell generally shorter than distance from its apex to wing tip, yellow spot on paraocular area usually



FIGS. 1-10. *Liphanthus (Liphanthus) sabulosus* Reed, male: 1, 2, 3, frontal, lateral and ventral views of head; 4, hind tibial spurs; 5, wings; 6, mandible; 7, labrum; 8, 9, seventh and eighth metasomal sterna; 10, dorsal and ventral views of genitalia.

FIGS. 11-15. *Liphanthus (Liphanthus) brevicornis* n. sp., male: 11, head frontal view; 12, labrum; 13, 14, seventh and eighth metasomal sterna; 15, dorsal and ventral views of genitalia.

extending farther below tentorial pit or touching epistomal suture, second submarginal cell with anterior margin distinctly shorter than posterior.

Male: Length about 6 mm, forewing length 4 mm, head width 2 mm, thoracic width 1.5 mm. *Coloration.* Head and thorax black, distal margins of clypeus and labrum brown, the following parts yellow: face below median ocellus and facial fovea, mandible (apex mahogany), middle part of underside of flagellum (sometimes extending to most of its ventral surface), pronotal

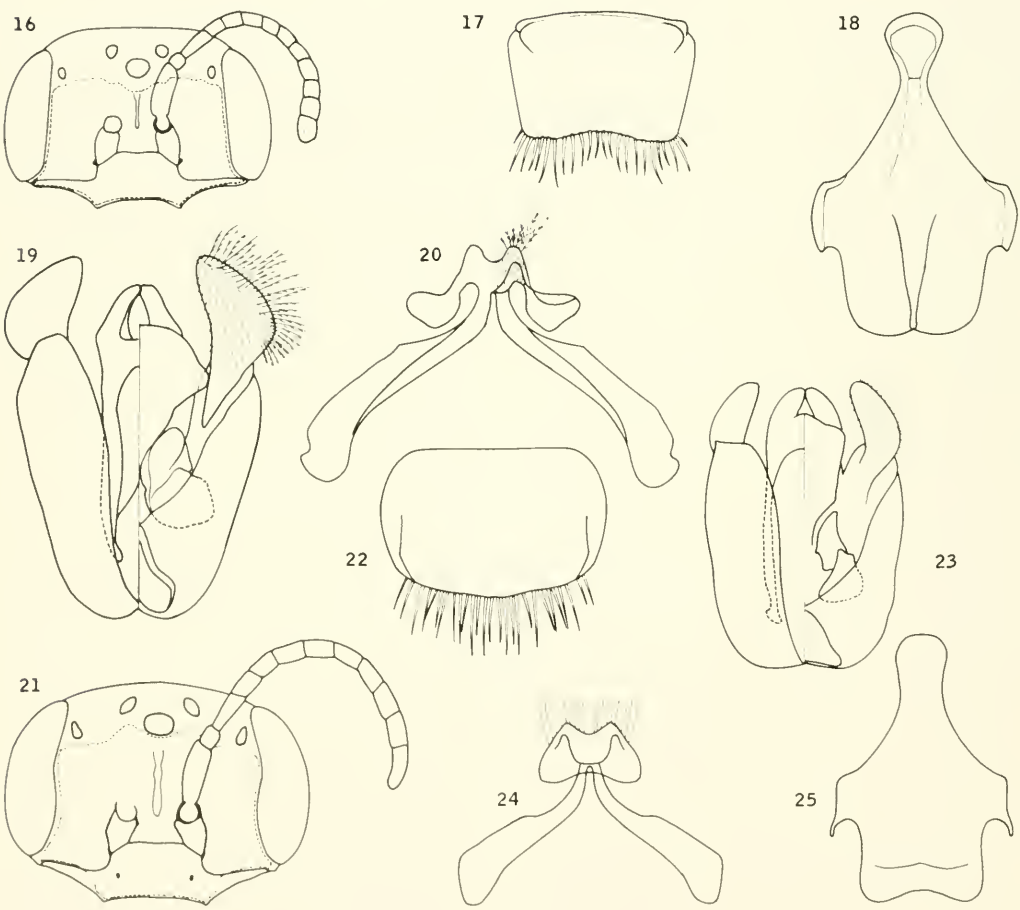
lobe, small spot on tegula, apex and part of ventral edge of fore femur, tibiae (except brown spot on both surfaces of tibiae I and II), tarsi (except small segments of hind tarsus which are brown). Wings slightly testaceous, veins brown. Tegula testaceous. Metasomal terga black with transverse yellow bands on terga I and II (wider on II). Metasomal sterna brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral areas of clypeus scarcely pubescent, with hairs shorter than those of labrum. *Integument and Punctation.* In general almost smooth, shiny on gena, and yellow parts of face, finely punctate on yellow parts, punctures somewhat denser and coarsest on clypeus, deeper on dorsal part of head, fine on dorsal part of thorax and sparse on hypoepimeral area, denser on rest of mesepisternum. *Structure.* Head approximately 1.4 times as broad as long. Flagellar segments somewhat longer than broad, last one about 2½ times as long as broad. Facial fovea about one-third as long as scape, usually oval (somewhat variable). Inner subantennal suture with upper part distinctly arcuate toward mid-line of face and shorter than width of subantennal area. Clypeus about 4 times as broad as long, projecting beyond lower orbital tangent for about one-third of its length, with a weak longitudinal protuberance. Labium flat, a little more than twice as broad as long, distal margin varies from slightly convex to almost straight. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 5.5 mm, forewing length 3.5 mm, head width 2 mm, thoracic width 1.5 mm. *Coloration.* Head and thorax black, flagellum brown beneath, the following parts yellow: area lateral to outer subantennal suture extending down below tentorial pit, usually touching epistomal suture, subantennal area, T-shaped spot on upper part of clypeus, base of mandible (apex mahogany), pronotal lobe, small spots on apices of fore and mid femora and bases of fore and mid tibiae and of basitarsi (the latter sometimes absent) (small segments of tarsi brown). Wings and tegula as described for male. Metasoma red, except most of segment I, lateral fovea on tergum II and distal margin of tergum V which are black and pygidial plate dark mahogany. Sterna II and III each with central area brown. *Pubescence.* As described for male, but denser and longer on head, mesepisternum and legs; tibial scopa less dense than hair of fore femur. *Integument and Punctation.* Head and thorax lightly, finely areolate, smooth on lower parts of face, gena, and pygidial plate apically, densely and coarsely punctate on head, sparser and coarser on clypeus, finer and denser above antennal sockets. Thorax with medium-sized punctures, sparse on discal part of scutum, deeper and sparse on scutellum, fine and sparse on hypoepimeral area, coarser and denser on rest of mesepisternum (sparser than *L. sabulosus*). *Structure.* As described for male except facial fovea about as long as scape, usually sinuate, widened distally. Clypeus somewhat more than three times as broad as long. Lower part of frontal line minutely grooved. Marginal cell usually shorter than distance from its apex to wing tip. Pygidial plate with rounded longitudinal median ridge on apex.

Type Material: Holotype male. Valparaíso Prov., El Granizo, Chile, XI-1964 (F. Rojas). *Allotype female.*

Valparaíso Prov., El Belloto, 30-X-66 (H. Toro), both in Toro collection. *Paratypes* (all from Valparaíso Prov., Chile, except as indicated). 16 males, Olmué, X-1917 (3 of them without abdomens) and 4 females, XI-1900 (P. Herbst); 1 male, El Salto, 2-II-1968 (H. Toro); 4 males, Granizo, XI-1964 (F. Rojas); 1 male, Granizo, XI-1964 (V. Cabezas); 5 females, Belloto, 22-X-1967 (H. Toro); 5 females, Belloto, 30-X-1966 (H. Toro); 1 female, Belloto, 19-XI-1966 (H. Toro); 1 female, Colliguay, 18-X-1964 (H. Toro); 3 females, El Salto, 29-X-1967 (H. Toro); 4 males, El Roble, 2100 m, 7-XI-1971 (H. W. Sielfeld); 1 female, Santiago Prov., road to Maitenes, Río Colorado, 31-X-1971 (J. G. Rozen, L. Peña); 2 females, O'Higgins Prov., Rancagua, 12-X-1964 (L. Marnef); 1 male, Cautín Prov., Temuco, XI-1900 (P. Herbst). Paratypes are deposited in the following collections: KU, AMNH, MNHN, CAS, MCZ, and UCV.

Etymology: The specific name is based on *brevis* (short) and *cornu* (horn) with reference to the short antenna.



FIGS. 16-20. *Liphanthus (Liphanthus) barbatus* n. sp., male: 16, head frontal view; 17, labrum; 18, eighth metasomal sternum; 19, dorsal and ventral views of genitalia; 20, seventh metasomal sternum.

FIGS. 21-25. *Liphanthus (Liphanthus) chillanensis* n. sp., male: 21, head frontal view; 22, labrum; 23, dorsal and ventral views of genitalia; 24, 25, seventh and eighth metasomal sterna.

Liphanthus (Liphanthus) barbatus
new species
Figs. 16-20; Map 1, 1

Diagnosis: Close to *L. sabulosus* but male with antenna gradually enlarged distally, lateral areas of clypeus with long pilosity and distal clypeal margin concave; female with longitudinal yellow band on clypeus, metasoma black, and punctures on mesepisternum shallow. See also the characters given in the key.

Male: Length about 5.5 mm, forewing length 3.5 mm, head width 2 mm, thoracic width 1.5 mm. *Coloration.* Head and thorax black, the following parts yellow: face below median ocellus and facial fovea (except lateral areas of clypeus which are mostly brown and supra-alveolar area which is black), labrum (with a dark spot in some specimens), mandible (apex mahogany), under side of most of flagellum (but with an oblique, dark spot on flagellar segments 2, 3, and 4), pronotal lobe, small spot on tegula, apices of femora (ventral edge of femur I), tibiae and tarsi (except a dark spot on internal side of tibia III and in some specimens distitarsi dark). Wings slightly testaceous, veins brown. Tegula testaceous. Metasomal segments black, terga I and II each with transverse yellow band (much wider on II). *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral areas of clypeus densely pubescent, with hairs longer than those of labrum. *Integument and Punctation.* Head and thorax areolate, smooth between punctures on ventral part of gena and yellow parts of face. Punctation rather coarse and moderately sparse on clypeus, denser on orbito-ocellar area and upper half of gena. Dorsal surface of thorax finely punctate, punctures fine and dense on hypoepimeral area, coarser on rest of mesepisternum. *Structure.* Head about 1.5 times as broad as long. Flagellar segments 1-8 longer than broad, 9-11 as long as broad, last one truncate. Facial fovea small, about one-third as long as scape. Inner subantennal suture with upper half slightly arcuate toward mid-line of face, about as long as width of subantennal area. Clypeus somewhat more than 4 times as broad as long, convex, projecting beyond lower orbital tangent for about one-third of its length. Labrum flat, somewhat broader than long, distal margin with central part emarginate. Mandible unmodified. Marginal cell distinctly shorter than distance from apex to wing tip. Second submarginal cell with anterior margin shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 6 mm, forewing length 4 mm, head width 2 mm, thoracic width 1.6 mm. *Coloration.* Head and thorax black, the following parts yellow: area lateral to outer subantennal suture extending down below tentorial pit (somewhat variable in size), subantennal area, longitudinal median spot on clypeus, mandible (apex mahogany), under side of flagellum (except most of basal segments and sometimes the distal ones, brown), pronotal lobe, spot on tegula, small spot on apices of fore and mid femora, bases of tibiae (somewhat extended on external side of tibia I). Wings and tegula as described for male. Metasomal terga black, pygidial plate dark mahogany; sterna brown. *Pubescence.* As described for male but much longer and denser on head, mesepisternum and legs; tibial scopa somewhat densely hairy but less dense than hair of fore femur. *Integument and Punctation.* Integument strongly areolate, almost dull between punctures. Punctures rather dense and coarse on clypeus, finer on rest of head.

Thorax with rather small, shallow punctures. Hypoepimeral area and rest of mesepisternum with punctation less dense and less deep than in male. Pygidial plate apically smooth. *Structure.* As described for male except: head 1.2 times as broad as long; facial fovea almost as long as scape and narrow. Clypeus three times as broad as long. Lower part of frontal line a narrow groove. Pygidial plate with narrow ridge on apex.

Type Material: Holotype male and allotype female. Malleco Prov., Icalma, Chile, 11-I-1979 (O. Martínez), in Toro collection. *Paratypes.* (All from Malleco Prov., Chile.) 5 males and 2 females, Galletuć, Lonquimay area, 9-12-I-1962 (L. Peña) (2 of the males parasitized by *Strepsiptera*); 4 males, Galletué at source of Bío-Bío, near Argentine border, 1-I-1968 (L. Peña); 3 females, Lago Icalma, Cordillera de Lonquimay, 15-I-1962 (no collector indicated); 1 male and 1 female, Lago Icalma, Cordillera Lonquimay, 7-I-1962 (both parasitized by *Strepsiptera*) (no collector indicated); 3 males, Icalma, 11-I-1979 (O. Martínez, E. Balart, L. Ruz); 1 male and 1 female, Icalma, 11-I-1979 (H. Toro); 5 females, Malleco, Lago Icalma, I-1962 (E. Reed). The paratypes are deposited in: AMNH, KU, MLP, MNBR, MNHN, FAUCH, UCV, and HT.

Comments: Among the paratypes parasitized by *Strepsiptera,* the female has retained normal characters. However, one male shows some features as if it were female, that is, reduced yellow marks on the face (wider than in female) and legs, broad metasoma without transverse yellow bands, smaller head, and short flagellum and not enlarged distally. The two other parasitized males, from approximately the same locality, show similar feminization, and also a narrow yellow band on the supraclypeal area.

Etymology: The specific name is a Latin adjective meaning bearded, referring to the dense and long pilosity on the latero-distal area of clypeus.

Liphanthus (Liphanthus) chillanensis
new species
Figs. 21-25; Map I, F

Diagnosis: Near to *L. sabulosus* but males smaller, the last flagellar segment with almost straight lateral margins and facial fovea about three times as long as broad; females with clypeus less than three times as broad as long, ocello-occipital distance similar to ocellar diameter, much shorter than in *L. sabulosus.* It differs from other species by the characters given in the key.

Male: Length about 4.5 mm, forewing 2.9 mm, head width 1.5 mm, thoracic width 1.2 mm. *Coloration.* Head and thorax black, the following parts yellow: face below median ocellus and facial fovea (except most of lateral area of clypeus which is almost black), labrum (proximal area) (brown distally), mandible (apex mahogany), under side of flagellum, pronotal lobe, spot on tegula, apices of femora, tibiae and tarsi (except distitarsi mostly brown and a brown spot on internal face of hind tibia and basitarsus). Wings slightly dusky, veins brown. Tegula testaceous. Metasomal terga black, terga I and II each with transverse yellow band (wider on II). Metasomal sterna dark brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral areas of clypeus scarcely pubescent, with hairs shorter than those of labrum. *Integument and Punctation.* Head and thorax strongly but finely areolate between punctures, yellow parts of face and most of gena smooth and shiny. Punctation, in general fine and sparse

on head and thorax, very fine and sparse on hypoepimeral area, deeper and denser on rest of mesepisternum. *Structure.* Head about 1.5 times as broad as long. Flagellar segments much longer than broad. Facial fovea about half as long as scape, almost straight. Inner subantennal suture with upper part arcuate toward mid-line of face, shorter than width of subantennal area. Clypeus broader than long, projecting beyond lower orbital tangent for somewhat less of half of its length, convex with median longitudinal protuberance. labrum flat, somewhat broader than long, distal margin convex. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 5.5 mm, forewing length 3.4 mm, head width 1.5 mm, thoracic width 1.2 mm. *Coloration.* Head and thorax black, flagellum light brown beneath, the following parts yellow: area lateral to outer subantennal suture extending slightly below tentorial pit, subantennal area, median longitudinal spot on clypeus, mandible (apex mahogany), pronotal lobe, spot on tegula, small spots on apices of fore and mid femora and bases of fore and mid tibiae (spot on ventral edge of tibiae I), external spot on basitarsi I and II (small segments of tarsi brown). Wings and tegula as described for male. Metasomal segments usually dark brown, sometimes reddish, pygidial plate mahogany. *Pubescence.* As described for male but longer and denser on head, mesepisternum and legs; tibial scopa somewhat densely pubescent but less dense than hairs of fore femur. *Integument and Punctation.* As described for male but densely and coarsely punctate on face, with smooth intervals between punctures below facial fovea. Pygidial plate areolate (or smooth) apically. *Structure.* As described for male except: head 1.3 times as broad as long, facial fovea half as long as scape, straight. Clypeus almost three times as broad as long. Lower part of frontal line unmodified except narrowly grooved apex. Pygidial plate with a narrow, median ridge apically.

Type Material: Holotype male and allotype female. Ñuble Prov., Chillán, Las Trancas, Chile, II-1977 (P. Toro), in Toro collection. *Paratypes.* (All from Ñuble Prov., Chile, except as otherwise indicated.) 3 females, Linares Prov., Castillo, II-1976 (H. Toro); 2 males and 1 female, Chillán, Trancas, II-1977 (P. Toro); 4 males, Chillán, Trancas, II-1977 (H. Toro); 2 males, Termas de Chillán, II-1976 (H. Toro); 1 male, Termas de Chillán, 15-III-1977 (E. Tosti); 2 males, Termas de Chillán (H. Toro); 1 male and 3 females, Termas de Chillán, 28-I-1967 (Schlinger). The paratypes are deposited in: KU, AMNH, CAS, UCV, and HT.

Etymology: The specific name refers to the area in which most of the specimens were collected.

Pseudoliphanthus new subgenus

Figs. 26-50

Type species: *Liphanthus rozeni* new species.

Both sexes: Vertex seen in frontal view convex. Lateral ocelli at about same level as or slightly below upper orbital tangent. Interalveolar area generally slightly protuberant and similar to supraclypeal area. Frontal line weak (except minutely grooved apex in male, sometimes carinate). Clypeus convex, lateral area sloping upward toward central area (widened laterally

in ventral view in male). Inner orbits not emarginate, divergent below. Distance between alveoli less than distance from alveolus to inner orbit, about two or more times alveolar diameter. Outer subantennal suture strongly arcuate laterally as in Figs. 26, 32, and 38 (less arcuate in *L. unifasciatus*). Pronotum without protuberant dorsolateral angle. Submarginal cells three. Propodeal triangle laterally more than half length of metanotum (laterally). Tibial spurs yellow or pale testaceous. Hind tibial spurs with apices slightly curved, inner slightly longer than outer.

Male: Head and legs with yellow marks, metasoma with one or two transverse yellow bands. Lateral area of clypeus with hairs sparse and shorter than clypeal length. Flagellum much longer than head, first flagellar segment approximately three times as long as broad. Facial fovea linear, shorter than scape, distance from its external margin to inner orbit similar to its width. Middle of paraocular area convex beside inner orbit, depressed toward alveolus; lower part of paraocular area sloping upward toward central area of face. Postmandibular area mesally much less than half as long as width of base of mandible. Sternum II produced into a spine (except in *L. unifasciatus*). Pygidial plate absent.

Female: Lower paraocular area and tegula without yellow. Tibial scopa about as dense as hairs of fore femur. Third flagellar segment broader than long.

Etymology: The subgeneric name is based on *pseudo*-false, plus the generic name, to indicate that the species of this subgenus look like those of the subgenus *Liphanthus s. str.*

Liphanthus (Pseudoliphanthus) rozeni
new species
Figs. 26-31; Map I, E

Diganosis: Similar to *L. sabulosus* but male with flagellar segments 2-10 a little longer than broad; metasomal sternum II with distal projection and sternum III with premarginal protuberance; female with upper half of face strongly areolate, dull and with punctures almost invisible.

Male: Length about 5 mm, forewing length 3.2 mm, head width 1.8 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax black, flagellum mostly testaceous beneath, the following parts yellow: face below facial fovea as in Fig. 26, labrum, mandible (apex mahogany), pronotal lobe, small basal spot on tegula, apices of femora, most of tibiae and basitarsi, small segments of fore and middle tarsi (brown on hind tarsus). Wings slightly testaceous, veins brown. Tegula testaceous. Metasomal terga black, I and II each with transverse yellow band (longer and wider on II). Metasomal sterna brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal fifth. Lateral area of clypeus scarcely pubescent, with hairs slightly longer than those of labrum. *Integument and Punctation.* Head and thorax strongly areolate, very dull on ocellar area, smooth and shiny on ventral paraocular area, clypeus and gena, with some striae in propodeal triangle. Metasoma smooth. Punctation in general shallow and fine, deeper on gena, coarser on clypeus, sparse on hypoepimeral area, well marked on rest of mesepisternum. *Structure.* Head 1.4 times as broad as long. Flagellar segments longer than broad, especially first and last one distinctly so. Facial fovea a little more than half as long as scape, convergent above. Inner subantennal suture slightly arcuate toward mid-line of face and distinctly shorter than width of subantennal area. Clypeus somewhat more than 4 times as broad as long, projecting beyond lower orbital tangent somewhat more than

half of its length, with median protuberance. Labrum flat, somewhat broader than long, distal margin broadly emarginate in the middle. Mandible with preapical widened plate (similar to that in Fig. 154). Marginal cell somewhat shorter than distance from apex to wing tip. Second submarginal cell with anterior margin about as long as posterior. Legs unmodified. Metasomal sternum II with postero-median projection much broader than long and hairy at apex (Fig. 30). Sternum III with premarginal protuberance on the midline; sternum IV slightly protuberant on the middle. Genitalia and associated sterna as illustrated.

Female: Length about 5.6 mm, forewing length 3.2 mm, head width 1.6 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax brown, the following parts yellow: spot on subantennal area, T-shaped spot on basal part of clypeus, mandible (apex mahogany), pronotal lobe, very small and weak spot on tegula, small spot on apices of fore and mid femora and bases of fore and mid tabiae (extending to external face on tibia I). Wings and tegula as described for male. Metasomal terga I-IV mostly yellowish (the rest testaceous), or in some specimens I and II each with distinct transverse yellow band (sometimes also on III); III and IV usually light testaceous (though somewhat variable in extent), remaining terga light brown (or darker). Pygidial plate mahogany. Metasomal sterna testaceous or brown. *Pubescence.* As described for male; tibial scopa somewhat densely pubescent, as dense as hairs of fore femur. *Integument and Punctation.* Integument in general areolate, but strongly areolate between punctures on upper half of face (mostly dull from alveolar level to vertex) and thorax, smooth on gena and metasomal terga; metasomal sterna almost smooth. Punctation as described for male but much denser and deeper on clypeus. *Structure.* As described for male except: head 1.3 times as broad as long, facial fovea somewhat more than half as long as scape and extremely narrowed on upper part. Clypeus depressed distally, somewhat more than three times as broad as long. Marginal cell about as long as distance from its apex to wing tip. Second submarginal cell with anterior margin shorter than posterior. Pygidial plate with median, longitudinal ridge on apex.

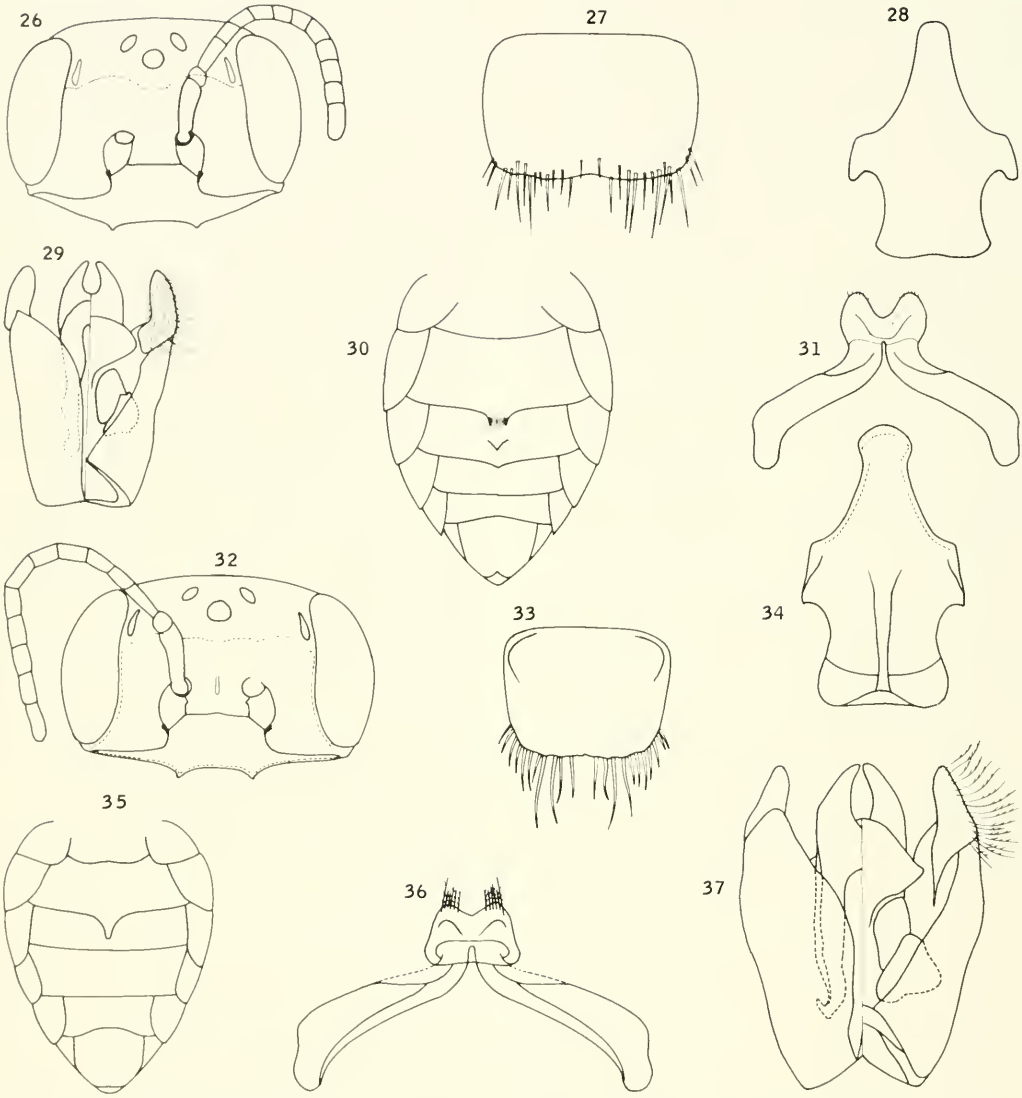
Type Material: Holotype male and allotype female. Talca Prov., Alto de Vilches, Chile, 15-XI-1969 (González), in Toro collection. *Paratypes.* 3 females, Talca Prov., Alto de Vilches, Chile, 30-X-1969 (J. G. Rozen, L. Peña). Paratypes are deposited in AMNH collection.

Etymology: This species is dedicated to Dr. Jerome G. Rozen, Jr., who has contributed greatly to the knowledge of the biology of Chilean insects and kindly helped us in several ways during this study.

Liphanthus (Pseudoliphanthus) spiniventris
new species
Figs. 32-37; Map I, G

Diagnosis: Similar to *L. sabulosus* but males with outer subantennal suture strongly arcuate and metasomal sternum II with a distal and median spine-like projection. See also the characters given in the key.

Male: Length about 5 mm, forewing length 3.2 mm, head width 1.8 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax black, the following parts yellow: face below level of facial fovea, labrum, mandible (apex mahogany), most of flagellum, pronotal lobe, small spot on tegula, apices of femora (continued along ventral edge



FIGS. 26-31. *Liphanthus (Pseudoliphanthus) rozeni* n. sp., male: 26, head frontal view; 27, labrum; 28, eighth metasomal sternum; 29, dorsal and ventral views of genitalia; 30, ventral view of metasoma; 31, seventh metasomal sternum.

FIGS. 32-37. *Liphanthus (Pseudoliphanthus) spiniventris* n. sp., male: 32, head frontal view; 33, labrum; 34, eighth metasomal sternum; 35, ventral view of metasoma; 36, seventh metasomal sternum; 37, dorsal and ventral views of genitalia.

of femur I), tibiae and basitarsi (small segments of mid and hind tarsi brown, small segments of fore basitarsus not observed). Wings slightly testaceous, veins and tegula dark testaceous. Metasomal terga black, I and II each with transverse yellow band (longer and wider on II). Metasomal sterna brown.

Pubescence. In general short and sparse. Labrum pubescent on distal fifth. Lateral area of clypeus scarcely pubescent, with hairs nearly as long as those of labrum. *Integument and Punctation.* Body in general strongly areolate, very dull between punctures in ocellar area, smooth and shiny on lower paraocular

area close to inner orbit and lower gena, with some striation on propodeal triangle. Punctation in general sparse and shallow, denser in orbito-ocellar area and gena, very fine on hypoepimeral area, denser and well marked on rest of mesepisternum. *Structure.* Head 1.5 times as broad as long. Flagellar segments much longer than broad. Facial foveae somewhat less than half as long as scape, convergent above. Inner subantennal suture with upper part angulate and distinctly shorter than width of subantennal area. Clypeus 4 times as broad as long, projecting beyond lower orbital tangent for somewhat less than half of its length, with basal and median protuberance. Labrum flat, a little broader than long, distal margin slightly excavated in middle. Mandible arcuate. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Mid basitarsus a little less than 3 times as long as broad. Metasomal sternum II with median spiniform projection on posterior margin (Fig. 35). Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Ñuble Prov., Chillán, Las Cabras, Chile, XII-1954 (L. Peña), in Toro collection.

Etymology: The species name refers to the acute spine on metasomal sternum II.

Liphanthus (Pseudoliphanthus) andinus
new species
Figs. 38-43; Map I, L

Diagnosis: Closely related to *L. spiniventris* but male with short and truncate projection on posterior margin of metasomal sternum II and flagellum somewhat longer than width of head; female recognizable by characters given in key.

Male: Length about 4.4 mm, forewing length 3 mm, head width 1.8 mm, thoracic width 1.6 mm. *Coloration.* Head and thorax black, most of flagellum brown, the following parts yellow: face below level of facial foveae, labrum (brown in center), mandible (apex mahogany), median part of under side of flagellum, pronotal lobe, very small spot sometimes on tegula (right side only in type), apices of femora (and ventral edge of femur I), tibiae and tarsi (except tibia and basitarsus III which are testaceous and small segments of tarsi I-III which are brown). Wings light testaceous, veins brown. Tegula testaceous. Metasomal terga black, terga I and II each with transverse yellow band (longer and wider on II). Metasomal sterna brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral area of clypeus scarcely pubescent, hairs longer than those of labrum. *Integument and Punctation.* Integument in general strongly areolate, very dull between punctures on ocellar area, more smooth and shiny on paraocular area from below facial fovea to its internal lobe beside clypeus, clypeus, and lower half of gena; with some striation on propodeal triangle. Punctation in general weak, fine and sparse, coarser on clypeus and denser on upper half of gena, very fine and sparse on hypoepimeral area, rest of mesepisternum with punctures somewhat bigger but weak. *Structure.* Head 1.5 times as broad as long. Flagellar segments much longer than broad. Facial fovea about half as long as scape, with upper part obliquely directed toward mid-line of face. Inner subantennal suture slightly arcuate toward mid-line of face and much shorter than width of subantennal area. Clypeus more than 4 times as broad as long, projecting beyond lower orbital tangent for about one-

third of its length, with a protuberance at base of central area. Labrum flat, somewhat broader than long, distal margin convex with median emargination. Mandible, in frontal view, with distal fourth curved (curvature varies from slight to strong). Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin slightly shorter than posterior. Mid basitarsus somewhat less than 3 times as long as broad. Metasomal sternum II with posteromedian projection about as long as apical width, apically truncate and densely hairy (Fig. 40). Genitalia and associated sterna as illustrated.

Female: Length about 4.6 mm, forewing length 3 mm, head width 1.4 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax black, the following parts yellow: T-shaped spot on upper part of clypeus, very small and weak spot on base of mandible (apex dark mahogany), spot on pronotal lobe, spot on tegula almost invisible (or absent), small spot on bases of fore and mid tibiae (prolonged to most of anterior border of tibia I). Wings lightly testaceous, veins and tegula brown. Metasoma black; pygidial plate sometimes mahogany. *Pubescence.* As described for male; tibial scopa as dense as hairs of fore femur. *Integument and Punctation.* In general finely and slightly areolate and shiny, a little more strongly areolate between punctures on upper part of face and thorax, somewhat opaque around ocelli. Pygidial plate smooth apically. Punctation as described for male but denser and deeper on face, absent around ocelli, coarser on clypeus, sparse on hypoepimeral area. *Structure.* As described for male except: head 1.4 times as broad as long, facial fovea straight, parallel to inner orbit, clypeus somewhat less than 3 times as broad as long, not protuberant.

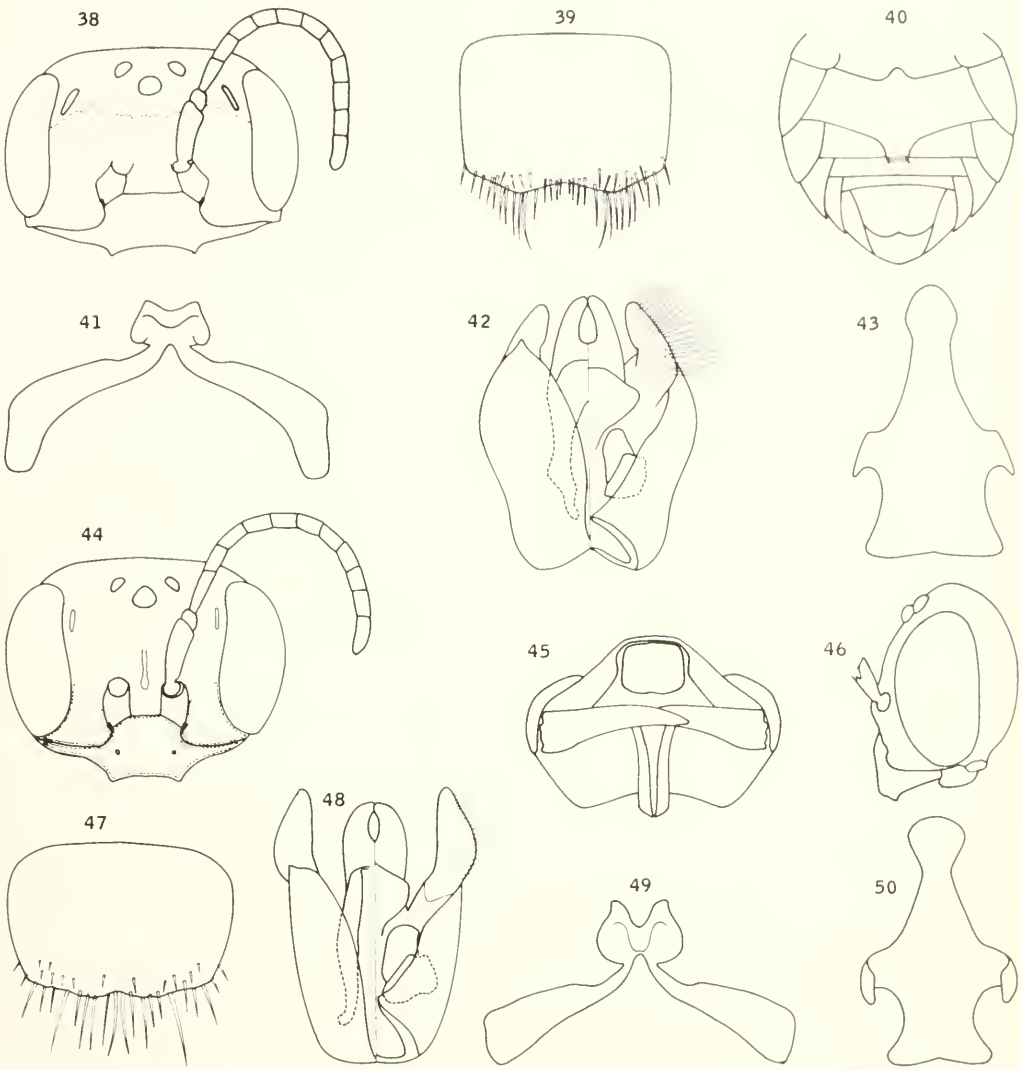
Type Material: Holotype male and allotype female. Malleco Prov., Cordillera, Nahuelbuta, Chile, IX-1980 (H. Toro), in Toro collection. *Paratypes.* 3 males and 1 female, Malleco Prov., Cordillera Nahuelbuta, Chile, IX-1980 (H. Donoso, H. Toro, H. Burgos); 1 male, Neuquén Prov., Lago Lacar, 650 m, Argentina, 15-I-1953 (Senkute). Paratypes are deposited in AMNH, KU, and UCV.

Etymology: The species name indicates the mountainous area where most of the specimens were collected.

Liphanthus (Pseudoliphanthus) unifasciatus
new species
Figs. 44-50; Map I, C

Diagnosis: Similar to *L. sabulosus* but male with frontal line carinate distally, face black from below alveolar level to vertex and metasoma with only one yellow transverse band. See also characters given in the key.

Male: Length about 4.6 mm, forewing length 3.4 mm, head width 1.7 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax black, the following parts yellow: lower part of paraocular area, clypeus, mandible (apex mahogany), labrum (darkened in the middle), pronotal lobe, weak spot on apices of femora, external surfaces of tibiae and basitarsi, hind tibia with dark area in middle; small segments of tarsi brown. Wings lightly testaceous, veins brown. Tegula testaceous. Metasomal terga black, with short and narrow transverse yellow band on II. Metasomal sterna dark brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral area of clypeus scarcely pubescent, hairs as long as those of labrum. *Integument and Punctation.* Head and thorax strongly areolate, lightly areolate between punctures on metasomal terga, smooth on metasomal sterna, with



FIGS. 38-43. *Liphanthus (Pseudoliphanthus) andinus* n. sp., male: 38, head frontal view; 39, labrum; 40, ventral view of metasoma; 41, seventh metasomal sternum; 42, dorsal and ventral views of genitalia; 43, eighth metasomal sternum.

FIGS. 44-50. *Liphanthus (Pseudoliphanthus) unifasciatus* n. sp., male: 44, 45, 46, head frontal, ventral and lateral views; 47, labrum; 48, dorsal and ventral views of genitalia; 49, 50, seventh and eighth metasomal sterna.

some striae on propodeal triangle. Punctation in general sparse and weakly marked, almost undistinguishable on face, coarser on clypeus, extremely fine on hypoepimeral area, somewhat coarse but weak on rest of mesepisternum. *Structure.* Head about 1.3 times as broad as long. Flagellar segments distinctly longer than broad. Facial fovea somewhat less than half as long as scape, narrow and straight. Inner subantennal suture slightly arcuate toward outer part of face. Clypeus more than 3 times as broad as long, projecting beyond lower orbital tangent for less than half its length. Labrum flat, less than twice as broad as long, distal margin slightly convex with

median shallow emargination. Mandible widened forming preapical plate (similar to Fig. 154). Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Valparaíso Prov., Valparaíso, Chile, 12-X-1971 (H. W. Sielfeld), in Toro collection. *Paratypes* (all from Chile). 3 males, Valparaíso Prov., Valparaíso, 12-X-1971 and 1 male, Valparaíso, 27 VIII-1972 (H. W. Sielfeld); 3 males without information about date, locality, and collector; 4 males, Valparaíso, IX-1920 (P. Herbst) and 4 males, Valparaíso Prov., Marga-Marga, from September to December, 1920 (P. Herbst). Paratypes deposited in: MCZ, CAS, and UCV.

Etymology: The specific name indicates that there is only one metasomal yellow band.

Xenoliphanthus new subgenus
Figs. 51-73

Type species: *Psaenythia parvula* Friese, 1916.

Both sexes: Vertex generally concave except almost straight in *L. micheneri* and *L. moldenkei*. Lateral ocelli at same level as upper orbital tangent. Interalveolar area usually convex, similar to supraclypeal area. Clypeus flat with longitudinal median groove; lateral area slightly sloping upward toward central area, widened mesally in ventral view. Inner orbits straight and parallel medially, divergent ventrally. Distance between alveoli similar to distance from alveolus to inner orbit and about twice as long as alveolar diameter. Outer subantennal suture arcuate laterally. Pronotum without protuberant dorsolateral angles. Submarginal cells three. Propodeal triangle laterally about as long as metanotum (laterally) or slightly shorter. Tibial spurs testaceous or brown. Hind tibial spurs with apices strongly curved, inner and outer subequal in length. *Male.* Head and legs with yellow marks, metasoma red to black, without yellow bands. Lateral area of clypeus with hairs sparse and shorter than clypeal length. Frontal line in shallow concavity basally. Flagellum a little longer than head; first flagellar segment 1.5 to 2.5 times as long as broad. Facial fovea linear, distance from it to inner orbit longer than its width. Middle of paraocular area convex beside inner orbit, slightly concave toward alveolus; lower part of paraocular area almost flat toward mid-line of face. Postmandibular area mesally much less than half as long as width of base of mandible. Sterna unmodified except male of *L. micheneri* has sternum II prominent mesally. Pygidial plate present. *Female.* Lower paraocular area without yellow spot. Tibial scopa less dense than fore femoral hairs. Third flagellar segment broader than long.

Etymology: The subgeneric name is from the Greek *xenos* meaning stranger plus *Liphanthus*.

Liphanthus (Xenoliphanthus) parvulus (Friese) new combination
Figs. 51-58; Map II, E

Psaenythia parvula Friese, 1916: 166; Herbst, 1922: 183; Jaffuel and Pirión, 1926: 369; Rozen, 1970: 146-147; Ehrenfeld and Rozen, 1977: 3.

Psaenythia pygmea Friese, 1916: 166; Herbst, 1922: 183.

Psaenythia friesei Herbst, 1922: 183 (new synonymy).

Male: Length about 5 mm, forewing length 4 mm, head width 1.7 mm, thoracic width 1.4 mm. *Coloration.*

Head and thorax black except flagellum mostly testaceous beneath, the following parts yellow: clypeus, lower part of paraocular area extending up beyond alveolar level, subantennal area, supraclypeal area, labrum (sometimes black or testaceous distally), mandible (apex mahogany), spot (sometimes absent) or under side of scape, pronotal lobe, spot on tegula, apices of femora, tibiae and most of basitarsi (small segments of tarsi brown). Wings slightly dark brown, veins brown, tegula testaceous. Metasoma red, black or basal and apical segments black, central segments reddish. *Pubescence.* In general short and sparse. Labrum pubescent on distal fourth. Lateral area of clypeus scarcely pubescent, with hairs shorter than those of labrum. *Integument and Punctation.* Integument in general smooth and shiny between punctures, except strongly areolate on upper half of face, slightly areolate on hypoepimeral area and metasomal sterna, scarcely striate on propodeal triangle. Punctation in general well marked, fine and dense on face, but coarse and sparse on lower part of paraocular area, clypeus and between inner orbit and lateral ocellus, fine but sparse on thorax, sparse on hypoepimeral area, coarser and somewhat denser on rest of mesepisternum. *Structure.* Head 1.6 times as broad as long. Flagellar segments somewhat longer than broad, first one more conspicuously longer. Frontal line carinate distally. Facial fovea elongate, straight, more than half as long as scape. Inner subantennal suture arcuate toward mid-line of face and slightly shorter than width of subantennal area. Interalveolar area protuberant. Clypeus somewhat less than 4 times as broad as long, projecting beyond lower orbital tangent for one-fourth of its length. Labrum strongly convex, more than twice as broad as long, distal margin with median, shallow emargination. Mandible unmodified. Marginal cell a little longer than distance from apex to wing tip. Second submarginal cell with anterior margin somewhat shorter than posterior. Legs and metasomal sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 6 mm, forewing length 4.1 mm, head width 2.2 mm, thoracic width 1.7 mm. *Coloration.* Head and thorax black, flagellum testaceous beneath, mandible mostly mahogany, the following parts yellow: small spot on pronotal lobe, apices of fore and mid femora, and bases of fore and mid tibiae. Wings and tegula as described for male, veins darker. Metasoma red-orange (sometimes with dark areas especially on last segments varying in extent), except lateral fovea on tergum II black and pygidial plate mahogany or black. *Pubescence.* As described for male, but tibial scopa less dense than hairs of fore femur. *Integument and Punctation.* Integument as described for male, but much smoother on face and mesepisternum. Hypoepimeral area scarcely punctate. Pygidial plate smooth or areolate. *Structure.* As described for male but facial fovea longer than scape and claws apparently simple. Pygidial plate with longitudinal ridge on apex.

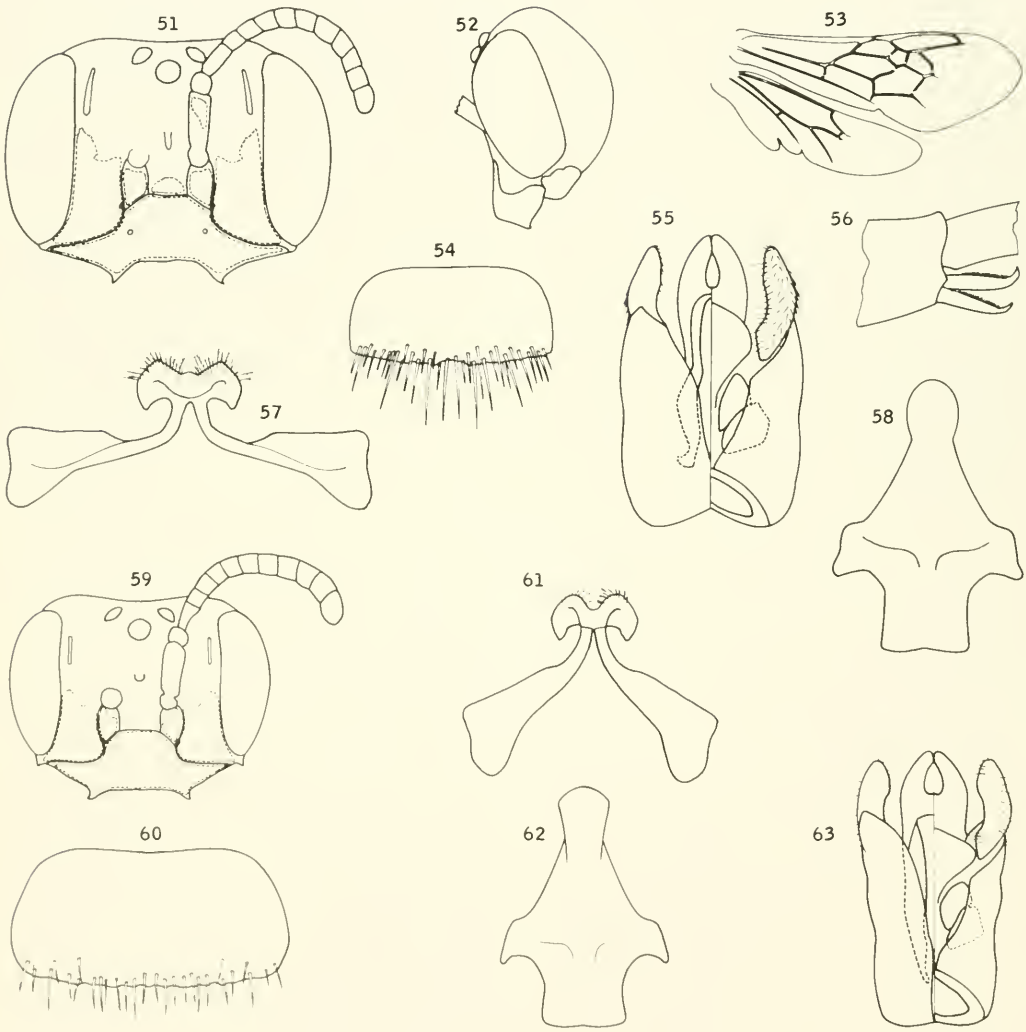
Material Studied (all from Chile): 3 females, Aconcagua Prov., Río Blanco, XII-1970 (M. Pino); 180 males and 61 females, Valparaíso Prov., diverse localities and collectors from September to January; 1 male, Santiago Prov., Santo Domingo, X-1966 (Ramírez).

Several specimens from Valparaíso have been collected on *Adesmia* sp.

Comments: Herbst (1922) recognized the synonymy of *pygmaea* and

parvula but unnecessarily erected a new name, *friesei,* for the species.

The type of *Psaenythia parvula* Friese, 1916, has apparently been lost. In the Berlin Museum, according to the information sent to Ruz by Dr. I. Wegener, there is only one female labeled as *P. parvula* Fr. It is from Valparaíso, Chile, X-1900 (P. Herbst), Friese determination, 1915; there is no type label on it. Since the authors have not seen the specimen from Berlin, a female from Valparaíso, Laguna Verde, Chile, I-11-1978 (L. Ruz) is here designated as the neotype, which will be deposited at the Universidad Católica de Valparaíso, Valparaíso, Chile.



FIGS. 51-58. *Liphanthus (Xenoliphanthus) parvulus* (Friese), male: 51, 52, head frontal and lateral views; 53, forewing and hindwing; 54, labrum; 55, dorsal and ventral views of genitalia; 56, hind tibial spurs; 57, 58, seventh and eighth metasomal sterna.

FIGS. 59-63. *Liphanthus (Xenoliphanthus) tofensis* n. sp., male: 59, head frontal view; 60, labrum; 61, 62, seventh and eighth metasomal sterna; 63, dorsal and ventral views of genitalia.

Liphanthus (Xenoliphanthus) tofensis
new species
Figs. 59-63; Map II, C

Diagnosis: Similar to *L. parvulus* but marginal cell distinctly longer than distance from apex to wing tip and hypoepimeral area with anterior part well punctate; female with frontal line ending in narrow groove apically instead of carina.

Male: Length about 5.4 mm, forewing length 3.5 mm, head width 1.6 mm, thoracic width 1.4 mm. *Coloration.* Head and thorax black, flagellum brown with under side mostly testaceous, the following parts yellow: clypeus, lower part of paraocular area extending near inner orbit up beyond alveolar level, subantennal area, supraclypeal area (sometimes black), labrum (testaceous distally), mandible (apex mahogany), spot (sometimes absent) on under side of scape, pronotal lobe, spot on tegula, apices of femora, tibiae and most of basitarsi (small segments of tarsi dark-brown). Wings slightly dark brown, veins brown, tegula testaceous. Metasomal segments reddish, tergum I and most of 2 or 3 last segments dark (brown or black areas varying in extent). *Pubescence.* In general short and sparse. Labrum pubescent on distal fourth. Lateral area of clypeus scarcely pubescent, with hairs about as long as those of labrum. *Integument and Punctation.* In general smooth and shiny between punctures, face with upper half strongly areolate and mesepisternum slightly areolate and dull, propodeal triangle scarcely striate. Punctation in general well marked, rather fine and dense on face, but coarse and sparse on lower part of paraocular area, clypeus and between inner orbit and ocellus. Thorax rather coarsely punctate, punctures dense on anterior part of hypoepimeral area and very dense on rest of mesepisternum. *Structure.* Head 1.3 times as broad as long. Flagellar segments about as long as broad, first and last longer. Frontal line a small groove apically, not carinated. Facial fovea straight, narrow, slightly shorter than half of scape. Inner subantennal suture arcuate toward midline of face and as long as width of subantennal area. Interalveolar area slightly prominent. Clypeus almost 4 times as broad as long, projecting beyond lower orbital tangent for about half its length. Labrum slightly convex, somewhat more than twice as broad as long, distal margin almost straight. Mandible unmodified. Marginal cell distinctly longer than distance from apex to wing tip. Second submarginal cell with anterior margin shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 6 mm, forewing length 4.5 mm, head width 2.2 mm, thoracic width 2.1 mm. *Coloration.* Black, flagellum testaceous beneath, brown above, the following parts yellow: small spot on pronotal lobe, spot on tegula, small spots on apices of fore and mid femora and bases of fore and mid tibiae (hind tibia and tarsi I-III brown). Wings as described for male. Metasoma red-orange, lateral fovea on tergum II black (sometimes with darkened areas on base of tergum I), pygidial plate mahogany. *Pubescence.* As described for male, tibial scopa less dense than hairs of fore femur. *Integument and Punctation.* As described for male but pygidial plate smooth. *Structure.* As described for male except head 1.5 times as broad as long, facial fovea somewhat narrower dorsally and almost as long as scape. Clypeus projecting beyond lower orbital tangent for less than half of its length. Claws apparently simple. Pygidial plate with no ridge apically.

Type Material: Holotype male and allotype female. Coquimbo Prov., El Tofo, Chile, X-1971 (H. Toro), in Toro collection. *Paratypes* (all from Coquimbo Prov., Chile). 2 males and 9 females, El Tofo, X-1971-72 (H. Toro); 1 female, El Pangue, X-1972 (H. Toro); 2 males and 2 females, Llano de la Higuera, N. of Tofo, 15-X-1971 (J. G. Rozen, L. Peña). Paratypes are deposited in the following collections: AMNH, KU, MNHN, and UCV.

Etymology: The name of the species is based on the type locality, El Tofo.

Liphanthus (Xenoliphanthus) moldenkei
new species
Figs. 64-68; Map II, H

Diagnosis: Closely related to *L. parvulus,* but vertex almost flat. Male with clypeus little more than 3 times as broad as long, with large black spot on each side basally. Female with claws cleft, inner ramus well developed.

Male: Length about 5.2 mm, forewing length 3.5 mm, head width 1.7 mm, thoracic width 1.5 mm. *Coloration.* Head and thorax black, flagellum testaceous beneath, labrum testaceous distally, the following parts yellow: clypeus (with black spot on each side basally), lower part of paraocular area extending nearly to inner orbit up to alveolar level, subantennal area (incompletely), labrum (except distal area), mandible (apex mahogany), small spot on under side of scape, pronotal lobe, small spot on tegula, apices of femora, tibiae and most of basitarsi (small segments of tarsi brown). Wings dark brown, veins mostly brown, tegula testaceous. Metasoma reddish, first two terga (especially lateral fovea of second), distal margin of fifth and pygidial plate darkened. *Pubescence.* In general short and sparse. Labrum pubescent on distal fourth. Lateral area of clypeus with hairs moderately long and sparse, about as long as those of labrum. *Integument and Punctation.* In general smooth and shiny between punctures, areolate on upper half of face and slightly so on mesonotum, hypoepimeral area and sterna; propodeal triangle scarcely striate. Punctation in general well marked, coarse and sparse on lower part of paraocular area, clypeus and orbitoocellar area. Thorax with punctures similar to those on upper face, moderately dense on scutal area, fine and dense on hypoepimeral area coarser, deeper on rest of mesepisternum. *Structure.* Head 1.4 times as broad as long. Flagellar segments almost as long as broad, first and last ones clearly longer. Frontal line evanescent distally. Facial fovea slightly sinuous, about as long as scape. Inner subantennal suture slightly arcuate toward mid line of face and about as long as width of subantennal area. Interalveolar area slightly prominent. Clypeus little more than 3 times as broad as long, projecting beyond lower orbital tangent for somewhat less than half of its length. Labrum convex, about twice as broad as long, distal margin slightly convex. Mandible unmodified. Marginal cell clearly longer than distance from apex to wing tip. Second submarginal cell with anterior margin somewhat shorter than posterior. Legs and sterna unmodified. Genitalia and associated sterna as illustrated.

Female: Length about 6.2 mm, forewing length 4.4 mm, head width 2 mm, thoracic width 1.8 mm. *Coloration.* Head and thorax black, the following parts yellow: most of under side of antennal flagellum, mandible (weakly yellow, apex dark mahogany), pronotal lobe, small spot on tegula, small spots on apices of femora and bases of fore and mid tibiae (somewhat elongate on anterior edge of tibia I). Wing, veins

and tegula as described for male. Metasoma orange-reddish, lateral fovea on tergum II black, metasomal terga I and II with darkened areas and pygidial plate mahogany. *Pubescence.* As described for male, but tibial scopa less dense than hairs of fore femur. *Integument and Punctation.* As described for male, but pygidial plate slightly areolate and hypoepimeral area sparsely punctate. *Structure.* As described for male except about half of frontal line in rather wide groove apically, clypeus somewhat more than 3 times as broad as long and pygidial plate with longitudinal ridge apically.

Type Material: Holotype male. Talca Prov., N. Laguna del Maule, 2,200 m, Chile, 16-I-1968 (Peña-Barros). *Allotype female.* Santiago Prov., La Ollita, Cantillana, 2,000 m, Chile, 1-8-XII-1969 (L. Peña), both in Toro collection.

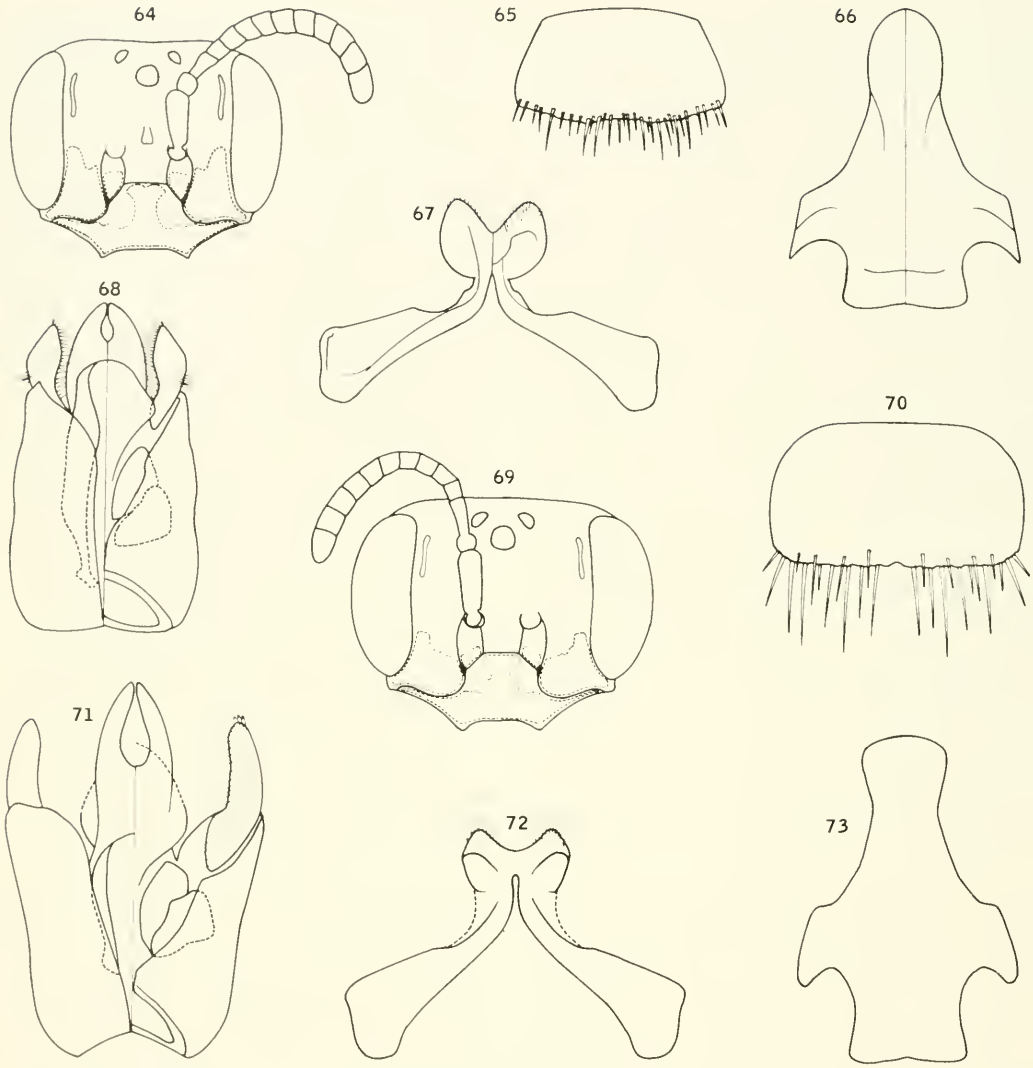
Comments: The association of sexes may not be correct since the male was collected at a different locality from that of the female.

Etymology: This species is named for Dr. Andrew Moldenke in recognition of his contribution to the study of the Chilean bees.

Liphanthus (Xenoliphanthus) micheneri
new species
Figs. 69-73; Map II, K

Diagnosis: Near to *L. parvulus* but male with black spot on each side of clypeus dorsally and 2 median protuberances on metasomal tergum II. Females with vertex flat and metasoma black.

Male: Length about 5.2 mm, forewing length 3.7 mm, head width 1.8 mm, thoracic width 1.5 mm. *Coloration.* Black, antennal flagellum testaceous beneath, the following parts yellow: clypeus except black spot on each side (very reduced and weak in some specimens, absent in others), lower part of paraocular area (sometimes extending up beside inner orbit to level of alveolus), part of subantennal area, small spot on supraclypeal area in some specimens, labrum (brown spot in the center in some specimens), mandible (apex mahogany), pronotal lobe, small spot on tegula, spots on apices of femora, tibiae and most of basitarsi (small segments of tarsi brown, except fore tarsal segments II-IV testaceous). Wings dark brown, Veins brown. Tegula testaceous. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral area of clypeus with hairs sparse, about as long as those of labrum. *Integument and Punctation.* In general almost smooth and shiny, except clearly areolate on dorsal half of face and thorax, coarsely and sparsely punctate in lower part of paraocular area, clypeus and orbito-ocellar area, scarcely so on striate propodeal triangle. Punctures weakly marked on scutal area and scutellum, finer and rather dense on hypoepimeral area. *Structure.* Head 1.4 times as broad as long. Flagellar segments about as long as broad, first and last longer. Frontal line in weakly marked apical groove. Facial fovea slightly S-shaped or straight, somewhat shorter than scape. Inner subantennal suture almost straight and about as long as width of subantennal area. Interalveolar area slightly prominent. Clypeus a little more than 3 times as broad as long, projecting beyond lower orbital tangent for somewhat less than half of its length. Labrum flat, almost twice as broad as long, distal margin straight. Mandible unmodified. Marginal cell a little longer than distance from apex to wing tip. Second submarginal with anterior margin somewhat shorter than posterior. Legs unmodified. Metasomal sternum II with 2 strong median



FIGS. 64-68. *Liphanthus (Xenoliphanthus) moldenkei* n. sp., male: 64, head frontal view; 65, labrum; 66, 67, eighth and seventh metasomal sterna; 68, dorsal and ventral views of genitalia.
FIGS. 69-73. *Liphanthus (Xenoliphanthus) micheneri* n. sp., male: 69, head frontal view; 70, labrum; 71, dorsal and ventral views of genitalia; 72, 73, seventh and eighth metasomal sterna.

protuberances side by side. Genitalia and associated sterna as illustrated.

Female: Length about 6 mm, forewing length 3.8 mm, head width 1.9 mm, thoracic width 1.8 mm. *Coloration.* Black, flagellum mostly testaceous beneath, brown above, the following parts yellow: weak spot on pronotal lobe, small spot on bases of fore and mid tibiae. Wings and tegula as described for male. Pygidial plate mahogany, with ridge black. *Pubescence.* As described for male but tibial scopa less dense than hairs of fore femur. *Integument and Punctation.* As described for male but pygidial plate almost smooth and punctures in general denser, especially on face except clypeus. Metasomal sterna coarsely punctate, punctures less deep and sparser on

metasomal terga, especially sparse on two first terga. *Structure.* As described for male, but head 1.6 times as broad as long, clypeus projecting beyond lower orbital tangent for a little more than half of its length. Pygidial plate with longitudinal ridge apically.

Type Material: Holotype male and allotype female. Ñuble Prov., Chillán, Las Trancas, Chile, XII-1977 (L. Ruz), in Toro collection. *Paratypes* (all from Ñuble Prov.), Chillán, Las Trancas, Chile, collected on 15-XII-1977). 60 males and 3 females (H. Toro), 73 males and 16 females (H. Flores), 52 males and 9 females (L. Ruz), 21 males and 1 female (E. Tosti-Croce), 44 males and 4 females (O Martínez), 34 males and 4 females (E. Chiappa), 12 males and 1 female (E. Peralta). Paratypes are deposited in the following collections: AMNH, CAS, KU, BMNH, MNHUB, IMZT, MNHNP, MNHN, MCZ, CONC, UCV, and HT.

Etymology: This species is named in honor of Dr. Charles D. Michener for all his suggestions in relation to this paper and his great contribution to the study of bees.

Discussion: A few more specimens, 4 males, Arauco Prov., Nahuelbuta, Chile, I-1979 (H. Toro, M. Cerda); 4 males and 2 females, Malleco Prov., Nahuelbuta, Chile, XI-1980 (diverse collectors) have also been examined. They are not paratypes because of the red metasoma of the females. This difference may indicate either intraspecific variation, or two closely related species. More material should be collected in the future.

Tricholiphanthus new subgenus

Figs. 74-89

Type species: *Liphanthus leucostomus* new species.

Both sexes (based on males only): Vertex slightly convex. Lateral ocelli at about same level as upper orbital tangent. Interalveolar area generally protuberant. Supraclypeal area variable. Clypeus usually slightly convex, without longitudinal median groove; lateral area slightly sloping upward to central area, widened mesally in ventral view. Inner orbits slightly emarginate in dorsal half (more broadly in *L. leucostomus*), generally divergent above, except subparallel in *L. tarsalis*. Distance between alveoli somewhat less than distance from alveolus to inner orbit and somewhat greater than diameter alveolus. Outer subantennal suture arcuate laterally. Pronotum with dorsolateral angle generally protuberant but less conspicuously so in *L. pilifrons*. Submarginal cells three. Propodeal triangle laterally almost as long as metanotum (laterally). Tibial spurs pale testaceous. Hind tibial spurs with apices slightly curved, inner slightly longer than outer.

Male: Head and legs with yellow marks, metasoma completely black. Pubescence in general rather long and dense. Lateral area of clypeus with hairs as long as or longer than clypeal length. Frontal line weakly marked, generally without groove distally but *L. pilifrons* with a minute one. Flagellum much longer than head; first flagellar segment about 3 times as long as broad. Facial fovea narrow, arcuate laterally, slightly shorter than scape and very close to inner orbit (more separated in *L. pilifrons* dorsally). Middle part of paraocular area flat, lower paraocular area slightly sloping toward center of face. Postmandibular area mesally much less than half as long as width of base of mandible. Sterna III and IV with shallow median emargination on posterior margin (barely concave on *L. pilifrons*). Pygidial plate absent.

Etymology: The prefix of the sub-

generic name is from the Greek *trichos* meaning hair, to indicate rather dense pilosity in the species here included.

Liphanthus (Tricholiphanthus) leucostomus new species
Figs. 74-79; Map I, Ch

Diagnosis: Close to *L. pilifrons* but clypeus and lower paraocular area whitish and sterna III and IV with posterior margins clearly concave; interalveolar area depressed.

Male: Length about 4.6 mm, forewing length 3.2 mm, head width 1.4 mm, thoracic width 1.2 mm. *Coloration.* Black, except flagellum mostly testaceous, the following parts yellowish white: clypeus, lower part of paraocular area extending up to level of lower margin of alveolus, labrum, mandible (apex mahogany), apex of pronotal lobe, spot on tegula, apices of femora, tibiae (except a brown spot on III) and most of basitarsi (small segments of tarsi brown). Wings scarcely testaceous, veins and tegula testaceous. *Pubescence.* Labrum pubescent on distal fourth. Clypeus with hairs much longer than those of labrum. *Integument and Punctation.* Dorsal part of head and thorax clearly areolate between punctures; lower half of face smooth and shiny; propodeal triangle striate; metasoma almost smooth. Punctation fine, shallow and sparse on upper head, discal area of scutum and scutellum, dense and fine in lower part of face and upper gena, very sparse and minute on hypoepimeral area, sparse and weak on metasomal sterna. *Structure.* Head 1.3 times as broad as long. Flagellar segments much longer than broad, last one strongly curved. Inner subantennal suture almost straight, a little shorter than width of subantennal area. Interalveolar area flattened. Supraclypeal area with median protuberance. Clypeus about 3 times as broad as long, projecting beyond lower orbital tangent for somewhat less than half of its length. Labrum little convex, broader than long, distal margin slightly convex, almost straight. Mandible unmodified. Pronotum with dorsolateral angle protuberant, acute. Marginal cell about as long as distance from apex to wing tip. Second submarginal cell with anterior margin slightly shorter than posterior. Legs unmodified. Metasomal sternum II with wide and truncate median projection on posterior margin (Fig. 78). Sterna III and IV posteriorly with broad, shallow median emargination. Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Santiago Prov., Cantillana, Chile, XII-1969 (L. Peña), in Toro collection. *Paratypes.* 9 males, same data; 1 male Santiago Prov., Cantillana, La Ollita, XII-1969 (L. Peña). The paratypes are deposited in the following collections: AMNH, KU, MNHN, UCV, and HT.

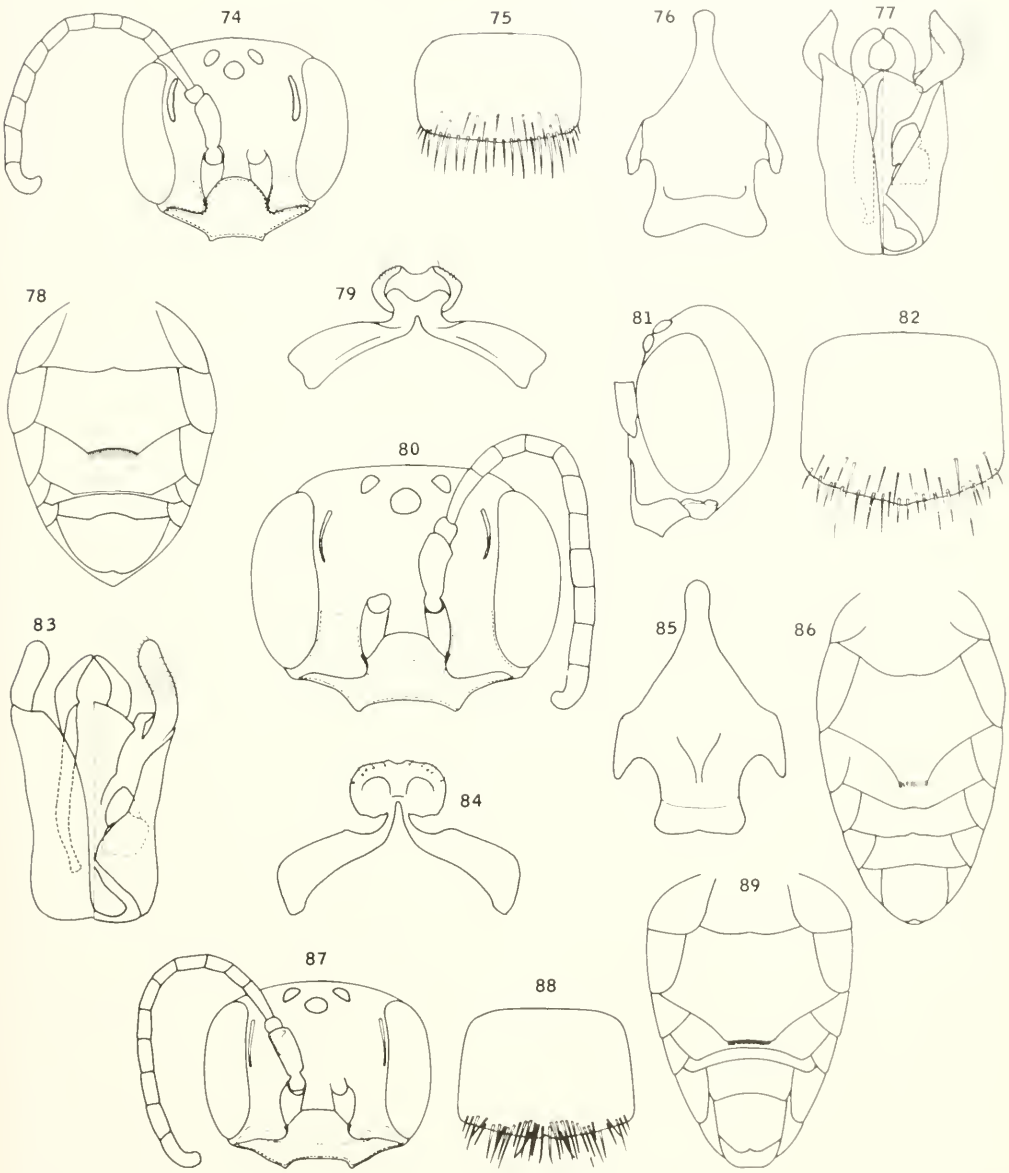
Etymology: The species name indicates the whitish color of clypeal area.

Liphanthus (Tricholiphanthus) pilifrons new species
Figs. 80-86; Map I, H

Diagnosis: Close to *L. leucostomus* but lower paraocular area and distal band of clypeus yellow, and posterior emargination of metasomal sternum III feeble and narrower; posterior margin of sternum IV almost straight; interalveolar area prominent.

Male: Length about 5.3 mm, forewing length 3.2 mm, head width 1.6 mm, thoracic width 1.3 mm. *Coloration.* Black, except flagellum mostly testaceous; the following parts yellow: paraocular area below level of alveolus, distal area on clypeus, labrum, mandible (apex mahogany), spot on scape distally, pronotal lobe, small spot on

tegula, apices of femora, tibiae and most of basitarsi (small segments of tarsi brown). Wings slightly testaceous, veins and tegula brown. Metasomal sterna dark brown. *Pubescence.* Labrum pubescent on distal fifth. Clypeus with hairs much longer than those of labrum. *Integument and Punctation.* Head and thorax strongly areolate between punctures, almost smooth on gena and



Figs. 74-79. *Liphanthus (Tricholiphanthus) leucostomus,* n. sp., male: 74, head frontal view; 75, labrum; 76, eighth metasomal sternum; 77, dorsal and ventral views of genitalia; 78, ventral view of metasoma; 79, seventh metasomal sternum.

Figs. 80-86. *Liphanthus (Tricholiphanthus) pilifrons* n. sp., male: 80, 81, head frontal and lateral views; 82, labrum; 83, dorsal and ventral views of genitalia; 84, 85, seventh and eighth metasomal sterna; 86, ventral view of metasoma

Figs. 87-89. *Liphanthus (Tricholiphanthus) tarsalis* n. sp., male: 87, head frontal view; 88, labrum; 89, ventral view of metasoma.

metasoma, striate on propodeal triangle. Punctures in general scarcely visible, more distinct in yellow areas of face, on gena and mesepisternum, very dense on metasomal terga. *Structure.* Head about 1.3 times as broad as long. Flagellar segments distinctly longer than broad, last one strongly curved. Inner subantennal sutures almost straight, convergent above and slightly shorter than width of subantennal area. Interalveolar and supraclypeal areas prominent. Clypeus flattened, more than 3 times as broad as long, projecting beyond lower orbital tangent for about half its length. Labrum convex, distal margin convex. Mandible unmodified. Pronotum with dorsolateral angle slightly protuberant. Marginal cell scarcely longer than distance from apex to wing tip. Second submarginal cell with anterior margin slightly shorter than posterior. Legs unmodified. Metasomal sternum II with broad postero-median projection (Fig. 86). Posterior margin of sternum III with shallow median emargination, that of IV almost straight. Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Ñuble Prov., Termas de Chillán, Chile, 18-I-1953 (L. Peña), in Toro collection. *Paratype.* 1 male, Ñuble Prov., Las Cabras, Chile, 6-31-I-1953 (L. Peña), deposited at KU.

Etymology: The species name is related to the moderately dense pubescence on the face.

Liphanthus (Tricholiphanthus) tarsalis
new species
Figs. 87-89; Map II, L

Diagnosis: Closely related to *L. leucostomus* but fore and mid tarsi with third segment more than twice as long as broad; upper part of clypeus flattened.

Male: Length about 4.8 mm, forewing length 3.6 mm, head width 1.4 mm; thoracic width 1.2 mm. *Coloration.* Black, antennal flagellum mostly testaceous; the following parts pale yellow: lower area on clypeus, lower part of paraocular area (narrow and transverse band), labrum, mandible (apex mahogany), spot on apex of scape beneath, pronotal lobe, spot on tegula, apices of femora, most of tibiae and tarsi (except distitarsi brown) of fore and mid legs, tibia III (except median dark area), first two segments of hind tarsus (rest of small segments of tarsi light brown). Wings almost hyaline. Tegula and veins dark testaceous. *Pubescence.* Labrum pubescent mesally on distal fifth. Clypeus with hairs much longer than those of labrum. *Integument and Punctation.* Head and thorax areolate and dull between punctures but almost smooth and shiny on yellow parts of face and gena as well as on metasoma, striate on propodeal triangle. Punctures scarcely visible except more distinct on yellow areas of face and on metasoma. *Structure.* Head 1.2 times as broad as long. Flagellar segments much longer than broad, last one strongly curved. Inner subantennal suture slightly arcuate toward midline of face and a little shorter than width of subantennal area. Interalveolar area distinctly prominent, supraclypeal area slightly protuberant. Clypeus flat, more than 3 times as broad as long, projecting beyond lower orbital tangent for about half of its length. Labrum slightly convex, broader than long, distal margin convex. Mandible unmodified. Pronotum with dorsolateral angle protuberant, acute. Marginal cell somewhat longer than distance from apex to wing tip. Second submarginal cell with anterior margin slightly shorter than posterior. Second segment of fore and mid tarsi narrow, about twice as long as broad

and similar to third. Hind basitarsus broadest at base, second tarsal segment almost as long as broad. Metasomal sternum II with wide truncate projection posteriorly (Fig. 89). Sterna III and IV each with broad median emargination on posterior margin. Genitalia and associated sterna missing in only specimen.

Type Material: Holotype male. Malleco Prov., Curacautín, Termas Tolhuaca, Chile, 20-I-1959 (L. Peña), in Toro collection.

Etymology: The species name refers to the modified tarsi.

Melaliphanthus new subgenus
Figs. 90-101

Type species: *Liphanthus atratus* new species.

Both sexes: Vertex convex. Lateral ocelli at same level as upper orbital tangent (male) or below (female). Interalveolar and supraclypeal areas protuberant. Frontal line weakly developed. Clypeus flattened basally (male) or slightly convex (female). Lateral area of clypeus abruptly sloping upward toward central area, widened mesally in ventral view. Inner orbits broadly emarginate in dorsal half and divergent above in male, almost straight and subparallel in female. Distance between alveoli similar to distance from alveolus to inner orbit and greater than alveolar diameter. Subantennal sutures almost straight. Pronotum without protuberant dorsolateral angle. Submarginal cells three. Propodeal triangle laterally more than half as long as metanotum laterally (slightly longer in female of *L. atratus*). Tibial spurs pale testaceous or brown. Hind tibial spurs with apices slightly curved, inner somewhat longer than outer.

Male. Head and legs with yellow marks, metasoma without yellow bands. Lateral area of clypeus with hairs sparse and shorter than clypeal length. Flagellum much longer than head; first flagellar segment about 3 times as long as broad. Facial fovea straight, length variable, fairly close to inner orbit. Middle of paraocular area convex, lower paraocular area abruptly sloping upward toward mid-line of face. Postmandibular area mesally half as long as width of base of mandible or more. Metasomal sternum II with postero-median projection. Pygidial plate absent.

Female: Lower paraocular area without yellow. Tibial scopa sparse, density similar to or less than that of fore femur. Third flagellar segment as long as broad or longer.

Etymology: The prefix comes from the Greek *melas,* black, since this is the predominant color in these species.

Liphanthus (Melaliphanthus) atratus
new species
Figs. 90-95; Map I, K

Diagnosis: Similar to *L. penai* but male with facial fovea almost half as long as scape and propodeal triangle distinctly striate; female with mandible mahogany only on distal third, frontal line in lower half a groove. See also characters given in the key.

Male: Length about 5.0 mm, forewing length 3.2 mm, head width 1.5 mm, thoracic width 1.3 mm. *Coloration.* Black, the following parts yellow: distal third of central area of clypeus, labrum, mandible (apex mahogany), anterior and outer surface of fore tibia and most of fore basitarsus, small spot on base and on apex of mid tibia, base of hind tibia, and small and weak spot on base of mid and hind basitarsus (small segments of fore tarsus and most of tarsi II and III brown or almost black). Wings almost hyaline, tegula and veins dark brown. *Pubescence.* In general short and sparse. Labrum

pubescent on distal margin. Lateral area of clypeus with hairs rather dense, as long as those of labrum. *Integument and Punctation.* Areolate between punctures, except smooth on yellow part of clypeus and on ventral paraocular area; propodeal triangle distinctly striate. Punctures hardly visible and sparse, better marked and denser on inferior paraocular area and lateral area of clypeus. *Structure.* Head 1.3 times as broad as long. Flagellar segments much longer than broad, the first one almost 3 times as long as broad. Facial fovea almost half as long as scape. Inner subantennal suture almost straight and distinctly longer than width of subantennal area. Clypeus about 3 times as broad as long, projecting beyond lower orbital tangent for about one-third of its length. Labrum smooth, slightly convex, less than twice as broad as long, distal margin with median part convex. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin shorter than posterior. Legs unmodified. Metasomal sternum II with acuminate postero-median projection extending forward in sternum as a ridge with a groove at its base, posterior margin laterally as indicated in Fig. 92. Metasomal sternum III posteriorly produced in the middle. Genitalia and associated sterna as illustrated.

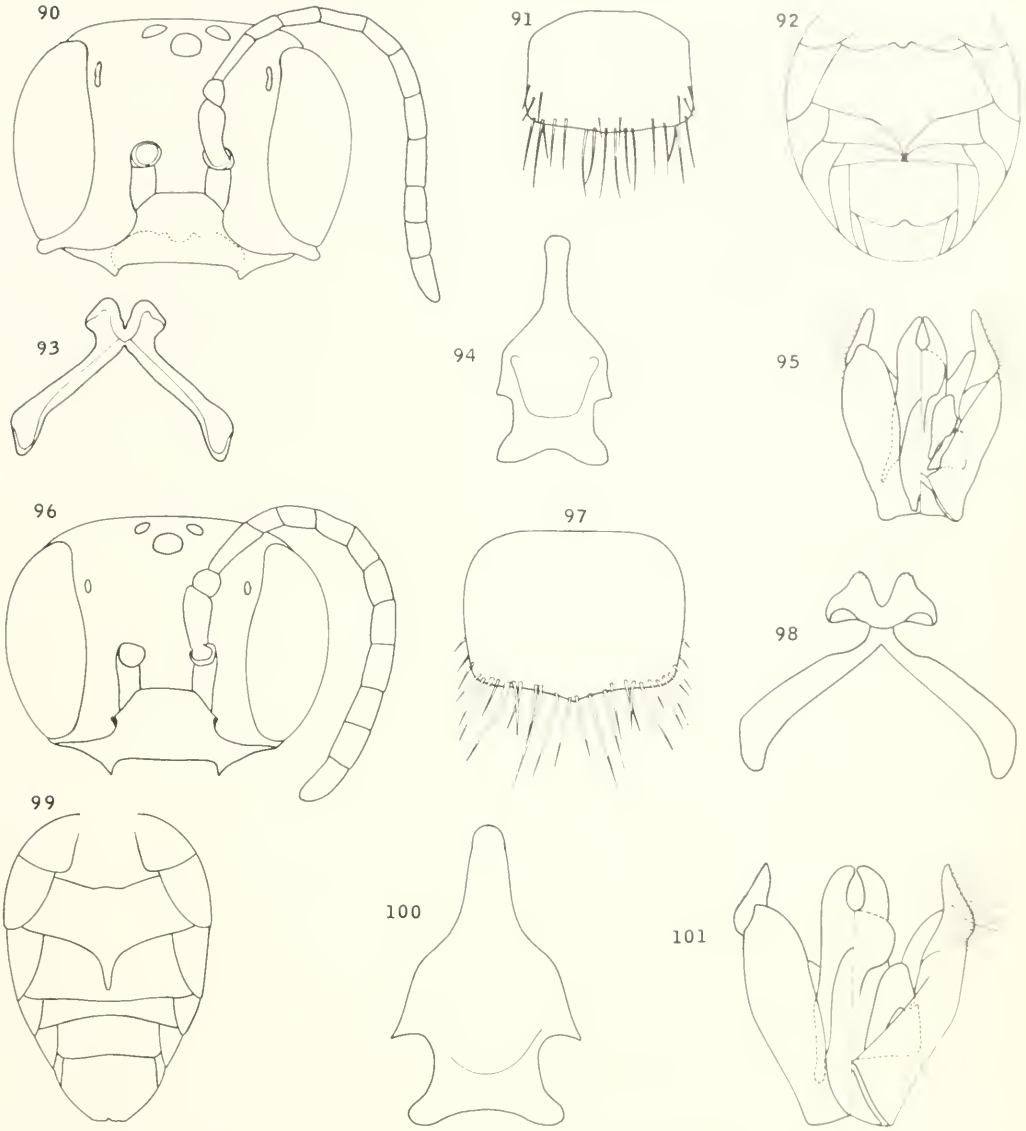
Female: Length about 5.6 mm, forewing length 3.7 mm, head width 1.6 mm, thoracic width 1.6 mm. *Coloration.* Black, except yellow and mahogany spot on distal third of mandible, weak yellow spot on anterior edge of fore tibia. Wings testaceous, veins and tegula dark brown. Pygidial plate mahogany. *Pubescence.* As described for male, tibial scopa rather sparse, density similar to that of hairs of fore femur. *Integument and Punctation.* In general areolate between punctures, clypeus with medium-sized punctures arranged in irregular longitudinal lines. Pygidial plate almost smooth apically. Punctation fine and somewhat dense on subantennal and supraclypeal area. Thoracic punctation sparse; weak and rather fine on metasoma. *Structure.* Head 1.2 times as broad as long. Frontal line, in lower half, a narrow groove. Facial fovea about three-fourths as long as scape. Subantennal suture as described for male. Clypeus less than 3 times as broad as long, projecting beyond lower orbital tangent for about half its length. Mandible, legs and marginal cell as described for male. Pygidial plate with slightly prominent longitudinal ridge on apex.

Type Material: Holotype male. Malleco Prov., Nahuelbuta, Chile, 9-I-1979 (L. Ruz). *Allotype female.* Same data but (H. Toro), both in Toro collection. *Paratypes.* Same locality and date, 2 females (E. Chiappa, H. Pastén), 4 females (P. Toro), and 1 male (E. de la Hoz); 1 female, Arauco Prov., Caramávida, Cordillera Nahuelbuta, 13-I-1967 (Schlinger), and 1 male, Arauco Prov., Nahuelbuta, I-1978 (M. Cerda). Paratypes are deposited in the following collections: AMNH, KU, CAS, UCV, and HT.

Etymology: The species name refers to its almost completely dark coloration.

Liphanthus (Melaliphanthus) penai
new species
Figs. 96-101; Map I, J

Diagnosis: Closely related to *L. atratus* but male with facial fovea very small, less than one-third as long as scape and propodeal triangle sparsely striate; female with mostly mandible yellow-mahogany, frontal line with lower part not a groove.



Figs. 90-95. *Liphanthus (Melaliphanthus) atratus* n. sp., male: 90, head frontal view; 91, labrum; 92, ventral view of metasoma; 93, 94, seventh and eighth metasomal sterna; 95, dorsal and ventral views of genitalia.
Figs. 96-101. *Liphanthus (Melaliphanthus) penai* n. sp., male: 96, head frontal view; 97, labrum; 98, seventh metasomal sternum; 99, ventral view of metasoma; 100, eighth metasomal sternum; 101, dorsal and ventral views of genitalia.

Male: Length about 4.4 mm, forewing length 2.8 mm, head width 1.4 mm, thoracic width 1.1 mm. *Coloration.* Head and dorsal part of thorax black, rest of the body brown, the following parts yellow: weak line on distal margin of clypeus, labrum, mandible (apex mahogany), spots on apices of femora, inner and outer surfaces of fore tibia, most of fore basitarsus, spot on base of mid and hind tibiae (small segments of fore tarsus and tarsi II and III brown). Wings lightly testaceous, veins and tegula dark testaceous. *Pubescence.* In

general short and sparse. Labrum pubescent on distal margin. Lateral area of clypeus with hairs rather abundant, slightly longer than those of labrum. *Integument and Punctation.* Strongly areolate and somewhat dull between punctures, except lightly areolate and shiny in propodeal triangle (also sparsely striate) and metasoma. Punctation weak, deeper on inferior paraocular area, very sparse on hypoepimeral area. *Structure.* Head 1.3 times as broad as long. Flagellar segments much longer than broad, the first one somewhat more than 3 times as long as broad. Facial fovea small, less than one-third as long as scape. Inner subantennal suture almost straight, slightly shorter than width of subantennal area. Clypeus more than twice as broad as long, projecting beyond lower orbital tangent for about one-fourth of its length. Labrum slightly convex, broader than long, distal margin lightly produced in middle. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin shorter than posterior. Legs unmodified. Metasomal sternum II with very acute postero-median projection (with median longitudinal groove at base), posterior margins of sternum II laterally gradually convergent toward projection (Fig. 99). Sternum III with posterior margin almost straight. Genitalia and associated sterna as illustrated.

Female: Length about 4.8 mm, forewing length 3.7 mm, head width 1.6 mm, thoracic width 1.6 mm. *Coloration.* Brown, almost black, except: mandible mostly yellow-mahogany, weak yellow band on anterior edge of fore tibia, weak yellow spot on base of mid tibia. Wings lightly brown, veins and tegula darker than in male. Pygidial plate dark mahogany. *Pubescence.* As described for male; tibial scopa less dense than hairs of fore femur. *Integument and Punctation.* In general areolate between punctures, with some striae in propodeal triangle. Clypeus with medium-sized punctures irregularly arranged, shallow in interalveolar area, sparse on thorax, rather fine in metasoma. Pygidial plate smooth. *Structure.* Head 1.2 times as broad as long. Frontal line, in lower half, hardly visible. Facial fovea little more than three-fourths as long as scape. Inner subantennal suture as described for male. Clypeus little less than 3 times as broad as long, projecting beyond lower orbital tangent for somewhat more than half of its length. Mandible and marginal cell as described for male. Pygidial plate with longitudinal ridge on apex.

Type Material: Holotype male. Malleco Prov., Río Blanco, Chile, II-1964 (L. Peña), in Toro collection. *Allotype female.* Malleco Prov., Río Blanco, Chile, II-1959 (L. Peña), in FAUCH collection. *Paratypes.* 3 females, Malleco Prov., Río Blanco, Curacautín, Chile, 1-5-II-1959 (L. Peña) deposited in the following collections: UCV and HT.

Etymology: This species is dedicated to Señor Luis Peña in recognition of his contributions to the knowledge of the insects of Chile.

NEOLIPHANTHUS NEW SUBGENUS
Figs. 102-108

Type species: *Liphanthus bicellularis* new species.

Both sexes: Vertex convex. Lateral ocelli above upper orbital tangent. Interalveolar and supraclypeal areas protuberant. Frontal line weakly marked, without groove on lower end. Clypeus convex basally, flat distally, without median longitudinal groove, lateral area slightly sloping upward toward central area, widened mesally in ven-

tral view. Inner orbits slightly emarginate in dorsal half (almost straight in female), divergent above. Distance between alveoli somewhat greater than distance from alveolus to inner orbit and longer than length of alveolar diameter. Outer subantennal suture almost straight. Pronotum without protuberant dorsolateral angle. Submarginal cells two. Propodeal triangle laterally less than half length of metanotum laterally (about half in female). Tibial spurs pale testaceous. Hind tibial spurs with apices slightly curved, inner somewhat longer than outer.

Male: Head and legs with yellow marks, metasoma without yellow bands. Lateral area of clypeus with hairs about as long as clypeal length and sparse. Flagellum much longer than head; first flagellar segment about twice as long as broad. Facial fovea short, well defined, close to inner orbit. Middle of paraocular area convex, lower part of paraocular area slightly sloping upward to central area. Postmandibular area mesally much less than half as long as width of base of mandible. Sterna II and III each with median apical projection. Pygidial plate absent.

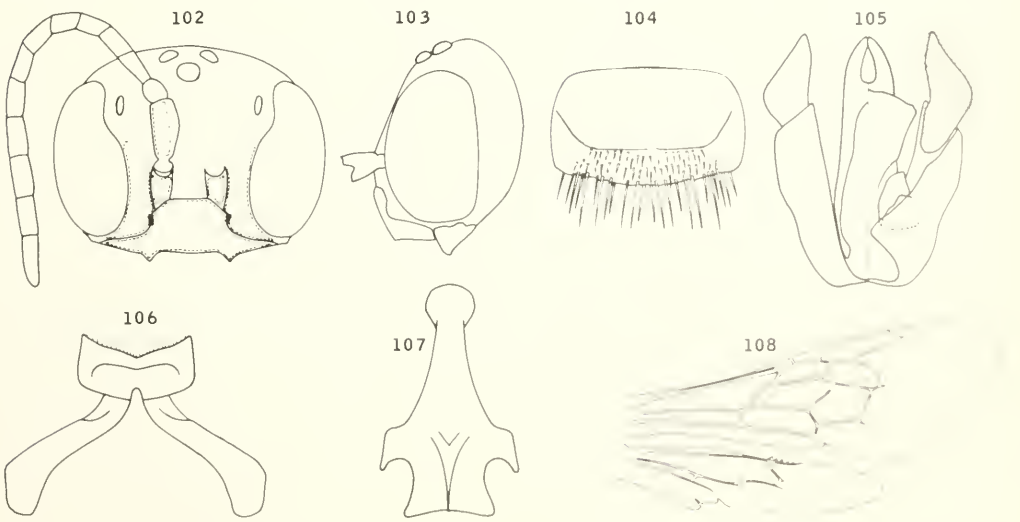
Female: Lower paraocular area without yellow spot. Tibial scopa sparse, with hairs as dense as those of fore femur. Third flagellar segment longer than broad.

Etymology: The subgeneric name is from the Greek *neos* meaning new plus *Liphanthus.*

Liphanthus (Neoliphanthus) bicellularis
new species
Figs. 102-108; Map II, J

Diagnosis: Similar to *L. nitidus* but both sexes with 2 submarginal cells, head about 1.3 times as broad as long, clypeus projecting beyond lower orbital tangent for less than half of its length, supra-antennal area distinctly areolate and dull. Male flagellum much longer than head.

Male: Length about 3.3 mm, forewing length 2.3 mm, head width 1.2 mm, thoracic width 0.8 mm. *Coloration.* Black, except most of flagellum testaceous beneath, the following parts



Figs. 102-108. *Liphanthus (Neoliphanthus) bicellularis* n. sp., male: 102, 103, head frontal and lateral views; 104, labrum; 105, dorsal and ventral views of genitalia; 106, 107, seventh and eighth metasomal sterna; 108, forewing and hindwing.

yellow: clypeus, lower part of paraocular area extending above alveoli, subantennal area, labrum, mandible (apex mahogany), under side of scape, pronotal lobe, apices of femora, tibiae, basitarsi and most of 2nd tarsal segments (rest of segments of tarsi brown). Wings almost hyaline, veins and tegula brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal third. Lateral area of clypeus scarcely pubescent, with hairs somewhat longer than those of labrum. *Integument and Punctation.* Head strongly areolate and dull, except weakly areolate or smooth and brilliant below alveolar level and lowest part of gena. Thorax slightly areolate, with some striae on propodeal triangle, smooth on metasoma. Punctures in general weak, fine and sparse, denser on most of gena and lower part of paraocular area, coarser on clypeus, very fine and sparse on hypoepimeral area, shallow on rest of mesepisternum. *Structure.* Head about 1.3 times as broad as long. Flagellar segments much longer than broad. Facial fovea elongate oval, less than half as long as scape. Inner subantennal suture almost straight, longer than width of subantennal area. Clypeus more than twice as broad as long, projecting beyond lower orbital tangent for one-fifth of its length. Labrum with transverse carina, pubescent at distal area, somewhat broader than long, distal margin lightly convex. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Legs unmodified. Sternum II with posterior margins laterally gradually convergent toward median spine-like projection (similar to Fig. 142, but projection very acute, straight, not hairy at apex). Sterna III and IV with posterior margins distinctly produced medially; sternum V with posterior margin slightly convex. Genitalia and associated sterna as illustrated. Sterna III and IV with posterior margins distinctly produced medially; sternum V with posterior margin slightly convex. Genitalia and associated sterna as illustrated.

Female: Length about 4.4 mm, forewing length 3 mm, head width 1.4 mm, thoracic width 1.3 mm. *Coloration.* Brown, almost black, the following parts yellow: T-shaped spot on upper part of clypeus (size somewhat variable), labrum (rarely), subantennal area (sometimes absent or asymmetrical), inner lobe of lower paraocular area (sometimes absent or asymmetrical), weak spot on mandible (apex mahogany), pronotal lobe, basal spot on each fore and middle tibia. Wings, veins and tegula as described for male. Pygidial plate mahogany. *Pubescence.* As described for male; tibial scopa sparse, hairs as dense as those of fore femur. *Integument and Punctation.* Integument as described for male except face more weakly areolate and shiny. Pygidial plate smooth apically. Punctation as described for male but deeper and denser on face, gena and hypoepimeral area. *Structure.* As described for male but facial fovea sinuous, more than half as long as scape, clypeus about 3 times as broad as long, projecting beyond lower orbital tangent for one-fourth of its length. Pygidial plate with longitudinal ridge on apex.

Type Material: Holotype male and allotype female. Linares Prov., Castillo, Chile, II-1976 (P. Toro), in Toro collection. *Paratypes.* Same locality and date, 14 males and 4 females (H. Toro), 2 males (H. Toro, Jr.), 6 males and 3 females (P. Toro); same locality, 10-II-1977, 3 males and 15 females (H. Toro), 2 males and 4 females (P. Toro). From Linares Prov., Bullileo, 15-XII-1977, 14 females (O. Mar-

tínez), 2 females (E. Chiappa, H. Toro), 4 females (E. Peralta) and 1 male (L. Ruz). Paratypes are deposited in the following collections: AMNH, KU, MNHN, CAS, FAUCH, and UCV.

Etymology: This species is called *L. bicellularis* because its forewings have only 2 submarginal cells.

Comments: The allotype, like some of the other female paratypes, lacks yellow on the face except for the mark on the clypeus.

Leptophanthus new subgenus
Figs. 109-151

Type species: *Psaenythia nigra* Friese, 1916.

Both sexes: Vertex convex. Lateral ocelli above upper orbital tangent. Interalveolar area in general little protuberant (more prominent in *L. cerdai*). Supraclypeal area in general protuberant. Clypeus protuberant without median longitudinal groove, lateral area abruptly sloping upward toward central area, widened mesally in ventral view (similar to Fig. 3). Inner orbits divergent above, slightly concave in upper halves, more distinctly concave in *L. nitidus* and *L. coquimbensis* (almost straight in females). Interalveolar distance longer than alveolorbital distance and about twice as long as alveolar diameter. Outer subantennal suture slightly arcuate laterally. Pronotum with dorsolateral angle not protuberant. Submarginal cells three. Propodeal triangle laterally more than half length of metanotum laterally (almost same length in *L. nitidus* and *L. alicahue*). Tibial spurs light yellow. Hind tibial spurs with apices slightly curved, inner slightly longer than outer. *Male.* Head and legs with yellow marks. Metasoma without yellow bands. Lateral area of clypeus with hairs sparse and shorter than length of clypeus. Frontal line generally well defined, in a wide depression basally (except *L. anacanthus* and *L. australis*). Flagellum little longer than head; first flagellar segment less than twice as long as broad. Facial fovea oval, shorter than scape, separated from inner orbit by a variable distance, borders sometimes not clearly defined. Median paraocular area generally slightly depressed toward mid-line of face; lower paraocular area strongly sloping upward toward mid-line of face. Postmandibular area mesally much less than half as long as width of base of mandible. Metasomal sternum II generally with median distal projection. Pygidial plate absent. *Female.* Inferior paraocular area without yellow (except in some specimens of *L. alicahue*). Tibial scopa of variable density. Third flagellar segment broader than long.

Etymology: The subgeneric name is from the Greek *leptos,* meaning thin, small (a common feature for the species here included) plus the major part of the generic name.

Liphanthus (Leptophanthus) nitidus new name
Figs. 109-114; Map II, G

Psaenythia nigra Friese, 1916: 167 (not *P. bizonata* var. *nigra* Friese, 1908: 41); Jaffuel and Pirión, 1926: 369.

Male: Length about 4 mm, forewing length 2.8 mm, head width 1.2 mm, thoracic width 1.0 mm. *Coloration.* Black, flagellum mostly testaceous, the following parts yellowish white: inferior paraocular area extending up to alveolar level, clypeus (sometimes black basally), labrum, mandible (apex mahogany), pronotal lobe, small spot on tegula, outer surface of fore tibia, bases and apices of mid and hind tibiae and most of basitarsi (rest of tarsi brown). Wings hyaline, veins and tegula testaceous. *Pubescence.* In general

short and sparse. Labrum pubescent on distal half. Lateral area of clypeus sparsely pubescent with hairs about as long as those of labrum. *Integument and Punctation.* Head and thorax almost smooth, shiny between punctures except areolate, dull on vertex; propodeal triangle striated. Punctures in general shallow, denser on lower half of face, somewhat coarse on clypeus, very fine and somewhat dense on hypoepimeral area, coarser and sparser on rest of mesepisternum. *Structure.* Head about as broad as long. Flagellar segments in general little longer than broad. Facial fovea in a smooth, shiny, long and wide groove, little more than half as long as scape, sometimes difficult to see. Inner subantennal suture almost straight and longer than width of subantennal area. Clypeus about twice as broad as long, projecting beyond lower orbital tangent for a little more than half of its length. Labrum convex, little less than twice as broad as long, with transverse carina at distal third, distal margin lightly concave. Mandible unmodified. Marginal cell longer than distance from apex to wing tip. Second submarginal cell with anterior margin about as long as posterior. Legs unmodified. Metasomal sternum II with postero-median spiniform projection, curved at apex; distal margin of sternum II strongly sinuous lateral to projection (Fig. 111). Sternum III with posterior margin slightly produced mesally. Genitalia and associated sterna as illustrated.

Female: Length about 4.9 mm, forewing 3.4 mm, head width 1.4 mm, thoracic width 1.2 mm. *Coloration.* Black, usually most of flagellum testaceous (sometimes with darker areas beneath, the rest brown, the following parts yellow: small spot (sometimes absent) distally on clypeus, preapical spot on mandible (mahogany) toward the apex, and small proximal spot on fore and hind tibiae. Tegula without yellow spot. Wings as described for male but veins darker. Pygidial plate brown. *Pubescence.* As described for male, but tibial scopa much denser than hairs of fore femur. *Integument and Punctation.* About as described for male but much coarser, with well marked punctures on clypeus, hypoepimeral area more densely punctate, propodeal triangle smooth and shiny, without striae. Pygidial plate smooth, shiny. *Structure.* As described for male except: head 1.1 times as broad as long, facial fovea about as long as scape, variable in shape (varies from wide to narrow, and from straight to sinuous), clypeus projecting beyond lower orbital tangent for more than half of its length, marginal cell shorter than distance from apex to wing tip. Pygidial plate with longitudinal ridge apically.

Material Studied (all from Chile): 3 males and 4 females, O'Higgins Prov., Termas de Cauquenes, 30-I-1972 (J. León) (1 female parasitized by Strepsiptera); 2 males and 2 females, Curicó Prov., Río Teno, Los Queñes, 14-II-1965 (L. Peña); 5 males and 19 females, Linares Prov., Longaví, IX-1980 (diverse collectors); 1 male and 11 females, Curicó Prov., Los Queñes, IX-1980 (diverse collectors); 1 female, Concepción Prov., Concepción, 1903 (P. Herbst); 1 male and 30 females, Bío-Bío Prov., Negrete, 31-XII-1950 (Ross and Michelbacher).

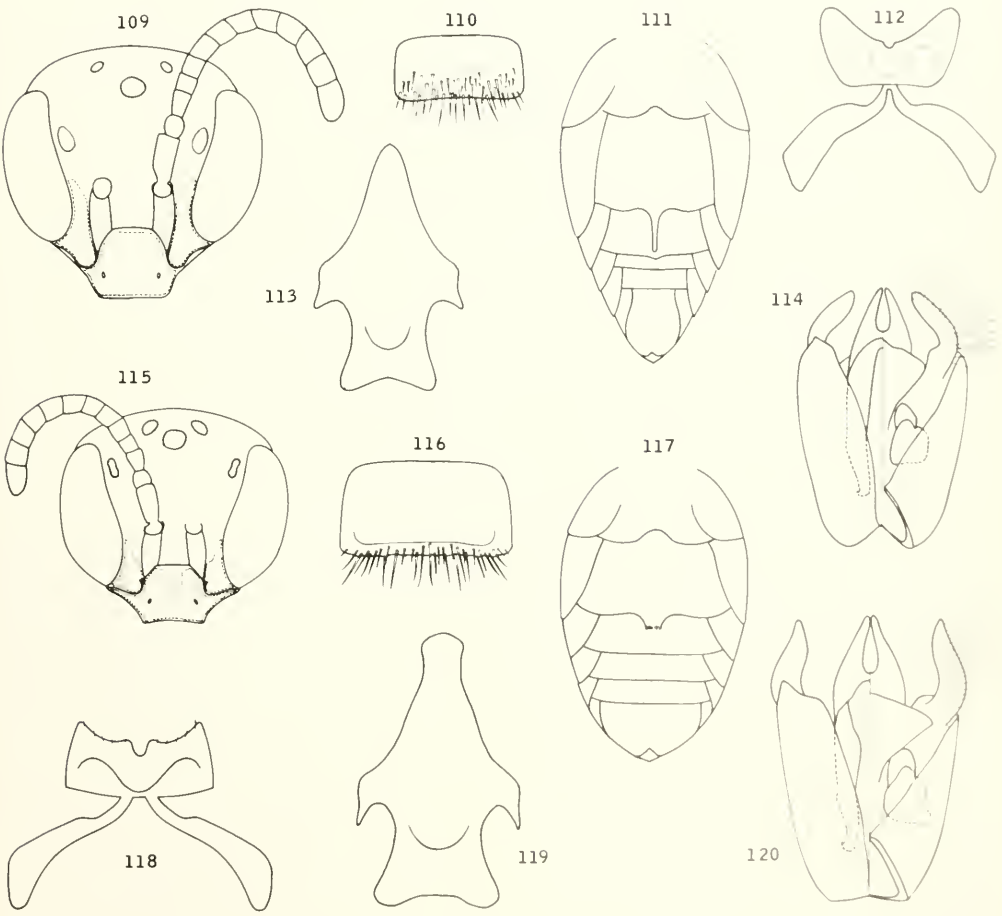
Etymology: The new name is the Latin word *nitidus,* meaning shiny.

Discussion: The type of *Psaenythia nigra* Friese, 1916, is perhaps lost. In the Berlin Museum there is a type labeled as *P. nigra* Fr., from Salta, Argentina, III-1905 (Steinbach). However, its correct name is *P. bizonata* var. *nigra* Friese, 1908, which is a real *Psaenythia.* According to the original

description of *P. nigra* Fr., 1916, males and females were collected in Concepción, Chile. One female from this locality (as mentioned in Material Studied) was found in the Museum of Comparative Zoology. It is here designated as the neotype.

The material studied was compared with the neotype and seems to be conspecific. However, females from Termas de Cauquenes show some differences, especially in the facial fovea, which is wider with poorly defined edges, and in the weaker punctation of the face. On the other hand females from Linares also show some variation in size and shape of the fovea. Since all the males studied look alike, all the specimens recorded in that paper have been considered conspecific.

More collections and especially males from Concepción should help to decide whether there is intraspecific variation or if closely related species are involved.



Figs. 109-114. *Liphanthus (Leptophanthus) nitidus* n. name, male: 109, head frontal view; 110, labrum; 111, ventral view of metasoma; 112, 113, seventh and eighth metasomal sterna; 114, dorsal and ventral views of genitalia
Figs. 115-120. *Liphanthus (Leptophanthus) breviceps* (Friese), male: 115, head frontal view; 116, labrum; 117, ventral view of metasoma; 118, 119, seventh and eighth metasomal sterna; 120, dorsal and ventral views of genitalia

Liphanthus (Leptophanthus) breviceps (Friese) new combination
Figs. 115-120; Map II, D

Psaenythia breviceps Friese, 1916: 167-168; Jaffuel and Pirión, 1926: 369.

Male: length about 4.2 mm, forewing 3 mm, head width 1.3 mm, thoracic width 1.1 mm. *Coloration.* Black, flagellum mostly testaceous beneath (rest of flagellum brown), the following parts yellowish white: most of clypeus, lower paraocular area (sometimes extending up to alveolar level), lower half (approximately) of subantennal area in some specimens, labrum, mandible (apex mahogany), pronotal lobe, apices of femora, tibiae (except tibiae II and III with brown spot on outer surface), most of basitarsi (small segments of tarsi brown). Wings dark-brown, veins light brown, tegula testaceous. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral area of clypeus scarcely pubescent with hairs little longer than those of labrum. *Integument and Punctation.* Head and thorax slightly areolate and shiny, smooth on face below alveoli level and most of gena, propodeal triangle with some striae. In general sparsely punctate, with punctures very sparse in hypoepimeral area above scrobe, deeper, coarser and denser on rest of mesepisternum. *Structure.* Head little broader than long. Flagellar segments little longer than broad. Facial fovea straight, narrow, about half length of scape. Inner subantennal suture almost straight, longer than width of subantennal area. Clypeus about twice as broad as long, projecting beyond lower orbital tangent for about half of its length or somewhat more. Labrum broader than long, flat basally, with transverse carina at distal fifth, distal margin almost straight. Mandible unmodified. Marginal cell slightly shorter than (sometimes equal to) distance from apex to wing tip. Second submarginal cell with anterior margin almost as long as posterior. Legs unmodified. Metasomal sternum II with short postero-median projection, little longer than its apical width, pubescent and curved downward at apex; distal margin of sternum II slightly sinuous lateral to projection (Fig. 117). Genitalia and associated sterna as illustrated.

Material Studied: 6 males, Aconcagua Prov., Río Blanco, Los Andes, Chile, 17-I-1969 (C. Vivar); 3 males, Aconcagua Prov., Las Coimas, 24-XI-1974 (L. Ruz); 1 male, Río Hornillos, Chile, 7-XII-1917 and 1 male same locality, 29-XII-1917 (P. Herbst).

Discussion: The type of *Psaenythia breviceps* Fr. has probably been lost. We have examined one male (mentioned in Material Studied) from the Berlin Museum labeled Río Hornillos, 7-XII-1917 (P. Herbst), "Typus" and *Psaenythia breviceps* Friese (1909, sic). However, this could not be the type, since its date of collection (1917) is later than the time of publication (1916). Moreover in Friese's original description males were reported from Victoria, Chile. We have not seen specimens from Victoria and have not been able to find the whereabouts of Río Hornillos. The specimen labeled Río Hornillos is here designated as the neotype, because it bears the "Typus" and identification label written by Friese.

Liphanthus (Leptophanthus) anacanthus new species
Figs. 121-126; Map II, F

Diagnosis: Similar to *L. nitidus* but male without spine-like projection on metasomal sternum II and labrum pubescent on distal fifth; female with

integument strongly areolate and opaque above alveoli.

Male: Length about 4.4 mm, forewing 2.8 mm, head width 1.4 mm, thoracic width 1.2 mm. *Coloration.* Black, flagellum brown, the following parts light yellow: clypeus (sometimes dorsal area black), spot on lower paraocular area extending up, close to inner orbit, to alveolar level, subantennal area (lower part), labrum, mandible (apex mahogany), small spot on tegula pronotal lobe, apices of femora, tibiae (except median dark spot on II and III), basitarsi, and second segment of hind tarsus (rest of tarsi brown). Wings slightly dark brown, veins brown, tegula testaceous. *Pubescence.* In general short and sparse. Labrum pubescent on distal fifth. Lateral area of clypeus sparsely pubescent, with hairs longer than those of the labrum. *Integument and Punctation.* Head and thorax areolate, more distinctly areolate and opaque on face above alveolar level, smooth and shiny on lower half of face and gena, propodeal triangle with some striae. Metasoma smooth. Punctation in general fine and rather sparse, somewhat denser on face distally, coarser on clypeus, rather sparse and very fine on hypoepimeral area, coarser on rest of mesepisternum. *Structure.* Head little broader than long. Flagellar segments longer than broad, first and second only slightly so. Frontal line, weakly distinguishable. Facial fovea in a somewhat shiny area beside inner orbit, straight, narrow, about half as long as scape. Inner subantennal suture straight and longer than width of subantennal area. Interalveolar area slightly prominent, clypeus about twice as broad as long, projecting beyond lower orbital tangent for about half (or less) of its length. Labrum less than twice as broad as long, flattened basally, with transverse carina at distal fifth, distal margin straight. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Legs unmodified. Metasomal sternum II without well-developed projection, mid-line posteriorly with short expanded and slightly bifurcate area, pubescent on margin; posterior margin of sternum II scarcely sinuous lateral to projection (Fig. 123). Genitalia and associated sterna as illustrated.

Female: Length about 5.4 mm, forewing 3.6 mm, head width 1.6 mm, thoracic width 1.5 mm. *Coloration.* Brown, almost black, flagellum testaceous beneath, the following parts yellow: mandible (apex mahogany), labrum, pronotal lobe, bases of tibiae. Wings, veins, and tegula as described for male. Pygidial plate dark mahogany. *Pubescence.* As described for male but tibial scopa as dense as hairs of fore femur. *Integument and Punctation.* As described for male, but pygidial plate slightly areolate and punctures deeper on lower half of face. *Structure.* As described for male except head 1.3 times as broad as long, facial fovea widened distally, longer than scape; metasoma unmodified, pygidial plate with longitudinal ridge.

Type Material: Holotype male and allotype female. O'Higgins Prov., Termas de Cauquenes, Chile, 30-I-1972 (J. León), in Toro collection. *Paratypes* (all from Chile). 9 males and 5 females, O'Higgins Prov., Termas de Cauquenes, 30-I-1972 (J. León); 21 males, O'Higgins Prov., Pangal, II-1978 (H. Flores); 3 females, Valparaíso Prov., Cuesta La Dormida, 30-XII-1971 (H. Toro); 1 male, Aconcagua Prov., Las Coimas, XI-1974 (L. Ruz). Paratypes are deposited in the following collections: AMNH, KU, MNHN, and HT.

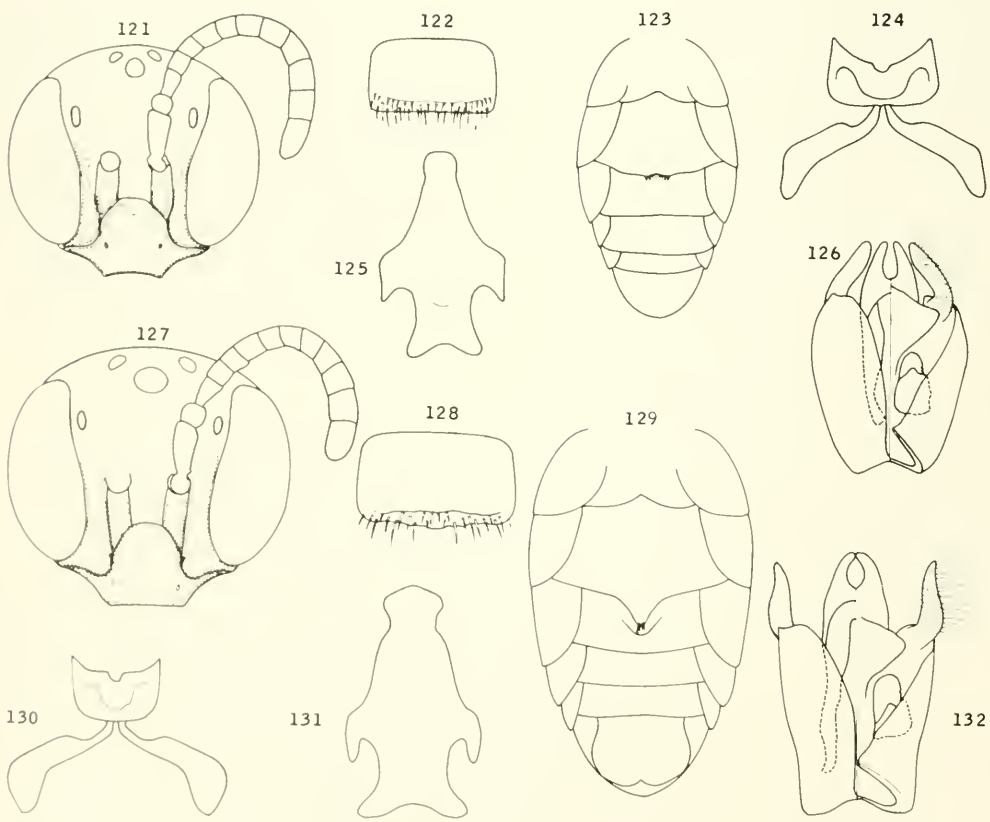
Etymology: The specific name refers

to the absence of a long spine on metasomal sternum II. Such a spine is present in most species of this subgenus.

Liphanthus (Leptophanthus) australis
new species
Figs. 127-132; Map II, N

Diagnosis: Similar to *L. nitidus* but male with projection of metasomal sternum II shorter and wider, labrum pubescent on distal fifth.

Male: Length about 4.1 mm, forewing 2.6 mm, head width 1.3 mm, thoracic width 1.1 mm. *Coloration.* Black, flagellum mostly testaceous beneath (rest of flagellum brown), the following parts light yellow: clypeus, lower paraocular area extending up to alveolar level (or a little further), subantennal area, labrum, mandible (apex mahogany), pronotal lobe, spot on tegula, apices of femora, tibiae, basitarsi and most of second segment of hind tarsus. Wings slightly testaceous, veins and tegula testaceous. *Pubescence.* In general short and sparse. Labrum pubescent on distal fifth. Lateral area of clypeus scarcely pubescent, hairs somewhat longer than those of labrum. *Integument and Punctation.* Areolate and somewhat opaque on head above alveolar level and on mesepisternum; rather smooth on lower half of face,



FIGS. 121-126. *Liphanthus (Leptophanthus) anacanthus* n. sp., male: 121, head frontal view; 122, labrum; 123, ventral view of metasoma; 124, 125, seventh and eighth metasomal sterna; 126, dorsal and ventral views of genitalia.
FIGS. 127-132. *Liphanthus (Leptophanthus) australis* n. sp., male: 127, head frontal view; 128, labrum; 129, ventral view of metasoma; 130, 131, seventh and eighth metasomal sterna; 132, dorsal and ventral views of genitalia.

gena and dorsally on thorax, propodeal triangle distinctly striated. Metasoma smooth. Punctation in general fine and not dense, deeper on lower paraocular area, coarse on clypeus, sparse on scutum, very fine and sparse on hypoepimeral area, coarser and denser on rest of mesepisternum. *Structure.* Head about as broad as long. Flagellar segments about as long as broad, first and last little longer. Frontal line weak toward base, with weakly grooved apex. Facial fovea elongate oval, less than half as long as scape. Inner subantennal suture almost straight and longer than width of subantennal area. Clypeus little more than twice as broad as long, projecting beyond lower orbital tangent for less than half of its length. Labrum less than twice as broad as long, with light transverse carina at distal fifth, distal margin almost straight. Mandible unmodified. Marginal cell longer than distance from apex to wing tip. Second submarginal cell almost rectangular, with anterior margin almost as long as posterior. Legs unmodified. Metasomal sternum II with short postero-median projection, about twice as long as broad (width measured at apex), pubescent at apex; posterior margins of the sternum gradually convergent toward projection (Fig. 129). Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Santa Cruz Prov., 2 km E Los Antiguos, 280 m, Argentina, 21-XI-1966 (Irwin and Schlinger), in Toro collection. *Paratypes.* 1 male, Santa Cruz, Argentina, 21-XI-1966 (Irwin and Schlinger), in UCV collection.

Etymology: The species name alludes to the austral distribution of this species.

Liphanthus (Leptophanthus) coquimbensis new species
Figs. 133-139; Map H, A

Diagnosis: Closely related to *L. nitidus* but male with transverse carina of labrum at distal fifth and metasomal sternum III with posterior margin straight mesally; female with clypeus generally black, basal yellow spot on mid tibia longer than last flagellar segment.

Male: Length about 3.6 mm, forewing 2.7 mm, head width 1.2 mm, thoracic width 1.0 mm. *Coloration.* Black, most of flagellum testaceous, the following parts light yellow: clypeus (dorsal part black in some specimens), inferior paraocular area usually extending up to alveolar level (sometimes reduced), usually lower half of subantennal area (approximately), labrum, weak basal spot on mandible (apex mahogany), pronotal lobe, apices of femora, most of fore tibia, bases (continued along dorsal edges) and apices of mid and hind tibiae (small segments of tarsi brown). Wings slightly brown, veins, tegula and last metasomal sternum testaceous. *Pubescence.* In general short and sparse. Labrum pubescent on distal fifth. Lateral area of clypeus sparsely pubescent with hairs somewhat longer than those of labrum. *Integument and Punctation.* In general shiny, slightly areolate between punctures on upper part of head. Rest of body in general smooth, but hypoepimeral area areolate; propodeal triangle shiny, apparently without striae, sometimes somewhat areolate. Head and thorax with rather fine and sparse punctures, denser and coarser on clypeus and mesepisternum, very fine and sparse on hypoepimeral area. *Structure.* Head scarcely broader than long. Flagellar segments little longer than broad, last one more distinctly so. Frontal line weak toward base, apically

in well developed groove. Facial fovea narrow, poorly defined. Inner subantennal suture slightly arcuate toward mid-line of face and little longer than width of subantennal area. Clypeus little more than twice as broad as long, projecting beyond lower orbital tangent for less than half of its length. Labrum less than twice as broad as long, with transverse carina at distal fifth, distal margin slightly concave. Mandible unmodified. Marginal cell about as long as distance from apex to wing tip. Second submarginal cell with anterior margin slightly shorter than posterior. Legs unmodified. Metasomal sternum II with posterior margin sinuous at each side and with median projection more than twice as long as broad (width measured at apex), curved downward at apex; posterior margin of sternum II distinctly sinuous lateral to projection (Fig. 139). Genitalia and associated sterna as illustrated.

Female: Length about 4.6 mm, forewing 3.6 mm, head width 1.5 mm, thoracic width 1.4 mm. *Coloration.* Black, small basal yellow spot on mandible (apex mahogany), rarely with yellow spot on clypeus. Wings, veins and tegula as described for male. Pygidial plate mahogany. *Pubescence.* As described for male; tibial scopa about as dense as hairs of fore femur. *Integument and Punctation.* Shiny as in male, but punctures much denser and much deeper on lower half of face, fine around alveoli, coarse and dense on clypeus. Pygidial plate smooth. *Structure.* As described for male but head 1.2 times as broad as long, facial fovea well developed, little longer than scape. Clypeus slightly more than twice as broad as long. Pygidial plate with longitudinal ridge on apex.

Type Material: Holotype male. Coquimbo Prov., Los Choros, Chile, 2-II-1972 (L. Ruz). *Allotype female.* Same locality and date as holotype (H. Toro), both in Toro collection. *Paratypes* (all from Chile). *Coquimbo Prov.* 2 females, 8 km W of La Junta, 4 females, 16 km W of La Junta and 1 female, 15 km W of La Junta, all 7-XII-1950 (Ross and Michelbacher); 5 females, 8 km N of Laguna Dam, 2.438 m elev., 6-XII-1950 (Ross and Michelbacher); 3 females, 32 km E of La Serena, 3-XII-1950 and 1 female, 40 km E of La Serena, 5-XII-1950 (Ross and Michelbacher); 36 males and 8 females, Río Los Choros, 6-XI-1956 (R. Wagenknecht); 5 males and 4 females, Rivadavia, 28-X-1957 (L. Peña); Choros Bajos, 12-X-1977, 4 males and 4 females (H. Toro), 8 males and 16 females (J. C. Magunacelaya), 12 males and 3 females (L. Ruz), 3 males and 1 female (E. de la Hoz), 2 males and 2 females (E. Balart), 1 male and 1 female (V. Cabezas), 9 males and 2 females (H. Flores), 1 male and 1 female (M. Rojas); Quebrada Los Choros, 12-X-1977, 4 females (V. Cabezas), 1 female (L. Ruz); Los Choros, 2-II-1972, 13 males and 7 females (H. Toro), 3 males and 7 females (H. W. Sielfeld), 7 females (M. Rojas), 19 males and 40 females (L. Ruz), 25 males and 40 females (M. Pastén), 2 males and 23 females (E. Montenegro), 1 female, 6-XI-1956 (R. Wagenknecht); 23 males, Alcones, 29-XI-1970 (M. Pino); 2 females, Río Choapa, I-1970 (H. Toro); 6 males and 2 females, La Serena, 1-III-1970 (M. Cerda); 3 males and 2 females, Hacienda Illapel, 19-X-1966 (Irwin, Schlinger, Peña); 1 male, Socos, 22-IX-1966 (Irwin); 1 male, Fray Jorge, 28-XII-1966 (Irwin); 1 male, Illapel, Huintil, 19-X-1966 (L. Peña); 2 males, Huanta, 6-I-1966 (L. Peña); 1 female, Buenos Aires, 2-XI-1954 (R. Wagenknecht). *Atacama Prov.* 2 females, Las

Juntas, IX-1968 (E. Montenegro); *Antofagasta Prov.* 1 female, Chiu-Chiu, 24-I-1972 (H. Toro). Paratypes are deposited in the following collections: AMNH, KU, NMNH, CAS, BMNA, IMZT, MUPA, CONC, MNHN, UCV, and HT.

Comment: The females of this species are difficult to separate from those of *L. nitidus*; the main differences are indicated in the key and diagnosis.

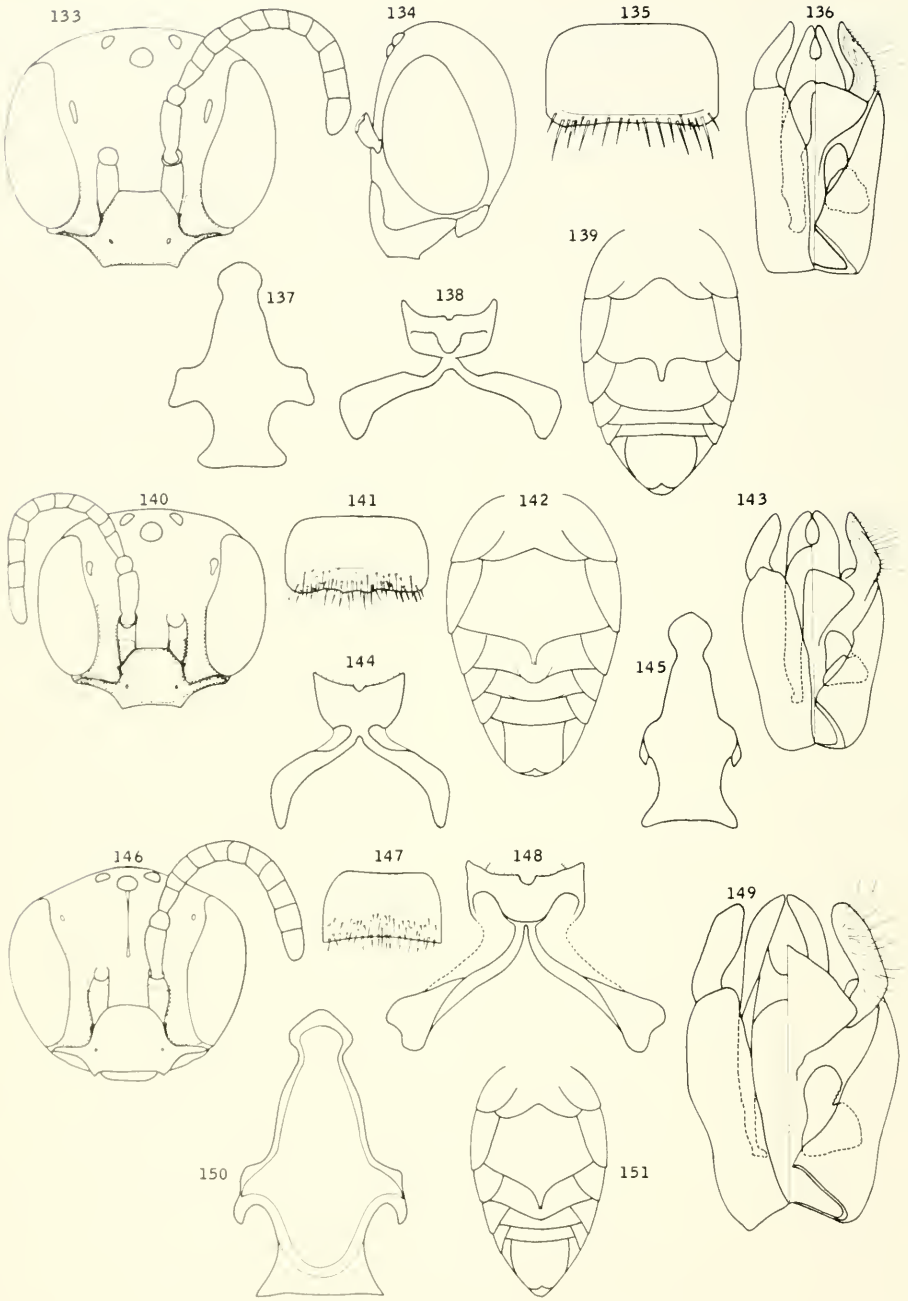
Etymology: The species is named for the Coquimbo region where most of the specimens have been found.

Liphanthus (Leptophanthus) cerdai
new species
Figs. 140-145; Map II, M

Diagnosis: Close to *L. nitidus* but male with head and thorax strongly areolate and frontal line almost carinate toward lower part and in minute groove; female strongly areolate and very finely punctate on face above alveolar level. See also characters given in the key.

Male: Length about 3.2 mm, forewing 2.4 mm, head width 1.1 mm, thoracic width 0.9 mm. *Coloration.* Black, flagellum mostly testaceous, the following parts yellow: clypeus, lower paraocular area extending up slightly beyond alveolar level, subantennal area (lower half), labrum, mandible (apex mahogany), pronotal lobe, apices of femora, outer surface of fore tibia, most of mid and hind tibiae except brown in the middle, spots on bases of fore and mid basitarsi and most of hind basitarsus (small segments of tarsi brown). Wings almost hyaline, veins and tegula brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal fourth. Lateral area of clypeus sparsely pubescent, hairs somewhat longer than those of labrum. *Integument and Punctation:* Head and thorax areolate between punctures, more strongly areolate and opaque above alveolar level, propodeal triangle with some striation. Metasoma smooth and shiny. Punctation on clypeus, coarser, denser, and deeper than on rest of face, shallow and sparse on thorax. *Structure.* Head 1.2 times as broad as long. Flagellar segments longer than broad, the second one slightly so. Facial fovea distinct, about one-third as long as scape. Inner subantennal suture almost straight, longer than width of subantennal area. Clypeus little more than twice as broad as long, projecting beyond lower orbital tangent for almost half its length. Labrum twice as broad as long, with weak transverse carina at distal fourth, distal margin slightly concave laterally. Mandible unmodified. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell rectangular, with anterior margin as long as posterior. Legs unmodified. Metasomal sternum II with postero-median acuminate projection, curved downward and hairy at apex, posterior margins of sternum laterally gradually convergent toward projection (Fig. 142). Sterna III and IV with posterior margins slightly produced mesally (more distinct on III). Genitalia and associated sterna as illustrated.

Female. Length about 4 mm, forewing 2.7 mm, head width 1.3 mm, thoracic width 1.2 mm. *Coloration.* Black, flagellum mostly testaceous, the following parts yellow: small apical spot on clypeus, weak spot on base of mandible, pronotal lobe, apices of femora, basal parts of mid and hind tibiae. Wings slightly dusky. Veins and tegula about as described for male. Pygidial plate dark mahogany. Metasomal sterna brown. *Pubescence.* As described for male; tibial scopa about as dense as hairs of fore femur. *Integument and Punctation.* As described for male



FIGS. 133-139. *Liphanthus (Leptophanthus) coquimbensis* n. sp., male: 133, 134, head frontal and lateral views; 135, labrum; 136, dorsal and ventral views of genitalia; 137, 138, eighth and seventh metasomal sterna; 139, ventral view of metasoma.

FIGS. 140-145. *Liphanthus (Leptophanthus) cerdai* n. sp., male: 140, head frontal view; 141, labrum; 142, ventral view of metasoma; 143, dorsal and ventral views of genitalia; 144, 145, seventh and eighth metasomal sterna.

FIGS. 146-151. *Liphanthus (Leptophanthus) alicahue* n. sp., male: 146, head frontal view; 147, labrum; 148, seventh metasomal sternum; 149, dorsal and ventral views of genitalia; 150, eighth metasomal sternum; 151, ventral view of metasoma.

but pygidial plate smooth and face less distinctly areolate and more densely punctate in its lower half, punctures very shallow on thorax. *Structure.* As described for male but head 1.3 times as broad as long, facial fovea elongated, little shorter than scape, inner subantennal suture as long as width of subantennal area, clypeus little less than 3 times as broad as long. Second submarginal cell with anterior margin slightly shorter than posterior. Pygidial plate without ridge apically.

Type Material: Holotype male. Malleco Prov., Nahuelbuta, Chile, II-1978 (P. Toro). *Allotype female.* Same locality and date (H. Toro), in Toro collection. *Paratypes* (all from Chile). 5 males and 4 females, Malleco Prov., Nahuelbuta, II-1978 (H. Toro); 2 males, same locality and date (P. Toro) and 2 males, without collector's name; 2 females, Malleco Prov., Nahuelbuta, 9-I-1979 (P. Toro) and 2 females, same locality and date (E. Balart); 8 males and 4 females, Malleco Prov. Angol, IX-1980 (E. de la Hoz, H. Toro, F. Rodríquez). Paratypes are deposited in the following collections: AMNH, KU, MNHN, and UCV.

Etymology: This species is dedicated to Dr. Miguel Cerda from the Instituto de la Patagonia (Chile), in appreciation of his contribution to the knowledge of the Chilean entomofauna.

Liphanthus (Leptophanthus) alicahue
new species
Figs. 146-151; Map II, B

Diagnosis: Close to *L. nitidus* but male with posterior margins of metasomal sternum II laterally gradually convergent toward median apical spine-like projection, face strongly areolate and dull above alveoli; female with longitudinal yellow band on clypeus.

Male: Length about 4.3 mm, forewing 2.8 mm, head width 1.3 mm, thoracic width 1.1 mm. *Coloration.* Black, flagellum mostly testaceous, the following parts yellow: clypeus, inferior paraocular area extending up beyond alveolar level, most of subantennal area, labrum, mandible (apex mahogany), pronotal lobe, weak spot on tegula, apices of femora, tibiae (but dark area in middle of tibiae II and III) and most of basitarsi (small segments of tarsi brown). Wings hyaline, veins and tegula testaceous. Metasomal sterna brown. *Pubescence.* In general short and sparse. Labrum pubescent on distal third. Lateral area of clypeus sparsely pubescent, with hairs somewhat longer than those of labrum. *Integument and Punctation.* Head on upper half strongly areolate and opaque, with punctures very fine, not dense and not distinct; lower half of head smooth, shiny and finely punctate except coarser punctures in central area of clypeus. Thorax almost smooth, shining, with well distinct and fairly dense punctures on scutum; hypoepimeral area areolate, with fine and sparse punctures, coarser and denser on rest of mesepisternum, propodeal triangle somewhat striated. *Structure.* Head slightly broader than long. Flagellar segments little longer that broad. Frontal line weakly defined on upper part, in a groove at lower apex. Facial fovea distinct, short, about one-fourth as long as scape. Inner subantennal suture almost straight, little less than twice as long as width of subantennal area. Clypeus little more than twice as long as broad, projecting beyond lower orbital tangent for half of its length. Labrum with weak transverse carina at distal third, little less than twice as broad as long, distal margin slightly concave. Mandible unmodified. Marginal cell about as long as distance from apex to wing tip. Second submarginal cell with anterior margin almost as long

as posterior. Legs unmodified. Metasomal sternum II with postero-median spine-like projection curved downward at apex; posterior margins of the sternum gradually convergent toward spine (Fig. 151). Metasomal sternum III with posterior part produced mesally. Genitalia and associated sterna as illustrated.

Female: Length about 5 mm, forewing 3.4 mm, head width 1.6 mm, thoracic width 1.4 mm. *Coloration.* Black, flagellum mostly testaceous, labrum testaceous, the following parts yellow: longitudinal median band on clypeus, small spot (sometimes absent) on inner lobe of lower paraocular area, mandible (apex mahogany), pronotal lobe, small spots on apices of femora and bases of tibiae. Wings slightly testaceous, veins and tegula testaceous. Pygidial plate mahogany. *Pubescence.* As described for male, though in general denser; tibial scopa as dense as hair of fore femur. *Integument and Punctation.* As described for male but propodeal triangle scarcely striated, shiny in middle; pygidial plate slightly areolate. *Structure.* As described for male except: head 1.2 times as broad as long; facial fovea somewhat wider, elongated, little shorter than scape; clypeus little less than 3 times broader than long. Marginal cell somewhat shorter than distance from apex to wing tip. Pygidial plate with wide longitudinal ridge on apex.

Type Material: Holotype male. Atacama Prov., Paipote, Chile, 20-X-1971 (J. G. Rozen, L. Peña). *Allotype female.* Same locality and collectors, 11-X-1971, both in AMNH. *Paratypes* (all from Chile). *Atacama Prov.* 23 males and 11 females, Paipote, 20-X-1971 (J. G. Rozen, L. Peña); same locality and collectors, 1 female, 11-X-1971, 14 males and 17 females, 12-X-1971; 13 males and 13 females, vicinity of Freirina, 14-X-1969 and 1 female, same locality, 15-X-1969; 1 female, 16-32 km S Copiapó, 18-X-1969; 6 males and 1 female, between Paipote and La Junta, 15-X-1969 (all the above collected by J. G. Rozen, L. Peña); 1 female, Vallenar, X-1972 (H. W. Sielfeld); La Junta, IX-1969, 1 female (E. Montenegro), 2 females (H. Toro), and 1 female (L. Ruz). *Coquimbo Prov.* Río Laguna, 3,000 m, I-1970, 1 male (L. Ruz), 1 male and 1 female (E. de la Hoz), 3 males (H. Toro). Paratypes are deposited in: AMNH, KU, NMNH, CAS, MNHN, UCV, and HT.

Etymology: The species name is derived from the *Mapuche* word *alicahue* which means "dried out place."

Comments: This species is mentioned by Ehrenfeld and Rozen (1977) as a small undescribed species of *Liphanthus* and a possible host of *Kelita tuberculata.*

Discussion: Besides the material mentioned above, the following series of other specimens, also from Chile, apparently belonging to the same species, have been examined: 6 females, Valparaíso Prov., Cuesta La Dormida, 21-XI-1971 (H. Toro); 4 males and 2 females, Aconcagua Prov., Riecillo, 20-I-74 (H. Toro, H. W. Sielfeld); 2 males and 1 female, Santiago Prov., Cajón del Yeso, 20-XI-1967 (Ramírez); 1 female, Santiago Prov., El Romeral, 9-XI-1967 (Ramírez); 1 female, Santiago Prov., Farellones, 1-I-1973 (A. Moldenke); 1 female, Santiago Prov., El Canelo, 9-I-1967 (Irwin); 1 female, same collector, Santiago Prov., Las Condes, 19-III-1966; 8 males and 8 females, Santiago Prov., Farellones, 8-I-1981 (H. Toro); 2 males and 2 females, same data (L. Ruz); 1 female, same locality, 27-XII-1979 (M. T. Arroyo); 1 male, Colchagua Prov., San Fernando, Ter-

mas del Flaco, II-1967 (H. Toro); 1 female, Curicó Prov., Los Queñes, Río Teno, 7-14-II-1965 (L. Peña); 5 males and 4 females, Ñuble Prov., Chillán, Las Cabras, 3-I-1963 (L. Peña); 2 females, Ñuble Prov., Las Trancas, from January to February (diverse collectors); 1 male and 3 females, Ñuble Prov., Termas de Chillán, II-1976 (H. Toro); 1 female, Malleco Prov., Icalma, II-1973 (H. Toro); 1 male, Santiago Prov., Cerros de Tiltil, 1700 m, 16-I-1919 (P. Herbst).

These specimens from central and southern Chile were not considered as paratypes.

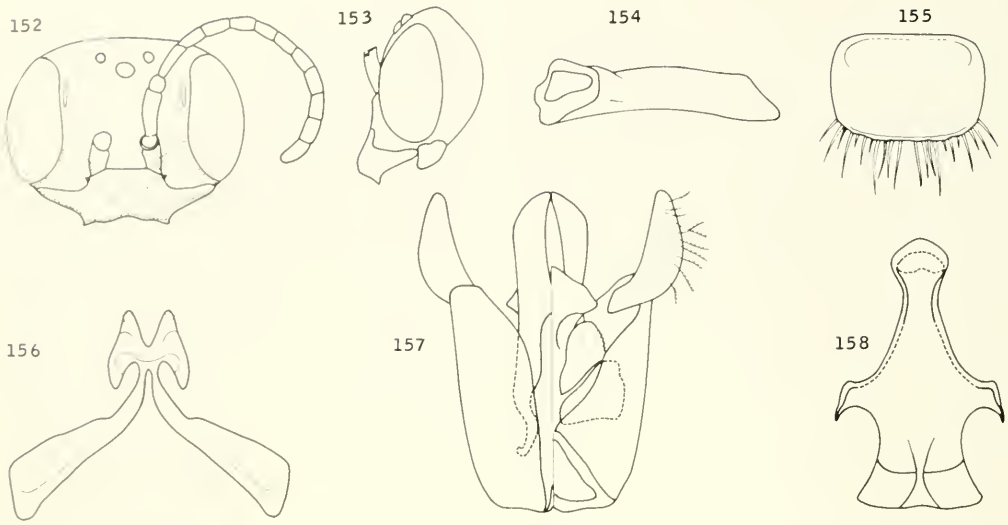
Assuming that all the specimens listed are conspecific, the geographic distribution of the species is from Malleco (south, central Chile) to Atacama in the north (letter B on Map II).

Species Not Assigned to Subgenus

Liphanthus friesellus new species
Figs. 152-158; Map I, D

Diagnosis: Similar to *L. (Pseudoliphanthus) unifasciatus* but male with clypeus, in side view, concave basally, its thickness (due to great protuberance) greater than length; upper and median paraocular areas distinctly depressed; interalveolar area slightly protuberant.

Male: Length about 4.4 mm, forewing 3.3 mm, head width 1.6 mm, thoracic width 1.2 mm. *Coloration.* Head and thorax light brown, the following parts yellow: clypeus distally, lower paraocular area below alveolar level, labrum (brown on median part), mandible (apex mahogany), small spot on pronotal lobe, spots on apices of femora (extending on ventral edge of femur II), most of tibiae (internal surface of each tibia and median area of external surface of II brown) and basitarsi (small segments of tarsi brown). Wings slightly testaceous, veins and tegula testaceous. Metasoma light brown, black distally, tergum II with transverse median yellow band. *Pubescence.* In general short and sparse. Labrum pubescent on distal margin. Lateral areas of clypeus somewhat pubescent, with hairs longer than those of labrum. *Integument and Punctation.* Slightly areolate, smoother and shiny on face; propodeal triangle scarcely striate. Punctures in general shallow and sparse, extremely fine on metasoma. *Structure.* Vertex slightly convex. Lateral ocelli at same level as upper orbital tangent. Head 1.3 times as broad as long. Inner orbit slightly concave medially. Interalveolar area prominent, somewhat less than distance from alveolus to inner orbit and about twice as long as diameter of alveolus. Supraclypeal area slightly convex. Flagellum distinctly longer than head, flagellar segments conspicuously longer than broad; first flagellar segment about 3 times as long as broad. Frontal line carinate, apex a minute groove. Facial fovea straight, narrow, about half as long as scape and about as broad as distance between its outer margin and inner orbit. Inner subantennal sutures converging above, each angulate in upper part and about as long as width of subantennal area; outer subantennal suture lightly arcuate laterally. Clypeus more than 3 times as broad as long, projecting beyond lower orbital tangent for more than half its length, in side view concave basally with weak longitudinal median ridge; lateral area abruptly sloping upward toward central area, widened laterally in ventral view. Labrum flat with marginal carina, broader than long, distal margin almost straight. Mandible curved, with widened preapical plate (Fig. 154).



FIGS. 152-158. *Liphanthus friesellus* n. sp., male: 152, 153, head frontal and lateral views; 154, mandible; 155, labrum; 156, seventh metasomal sternum; 157, dorsal and ventral views of genitalia; 158, eighth metasomal sternum.

Median paraocular area depressed; lower paraocular area strongly sloping upward toward mid-line of face. Postmandibular area mesally much less than half as long as width of base of mandible. Pronotum with dorso lateral angle not protuberant. Marginal cell shorter than distance from apex to wing tip. Second submarginal cell with anterior margin distinctly shorter than posterior. Propodeal triangle laterally more than half as long as metanotum laterally. Legs unmodified. Hind tibial spurs with apices slightly curved, inner slightly longer than outer. Metasomal sterna unmodified. Genitalia and associated sterna as illustrated.

Type Material: Holotype male. Colchagua Prov. (Pichilemu), Chile, X-1929 (F. Ruiz), in Toro collection.

Etymology: This species is dedicated to H. Friese who apparently recognized it as new.

Discussion. Specimens of *Liphanthus friesellus* have been found identified in collections with a Friese manuscript name (in the genus *Psaenythia*) referring to the long antennae. This name was listed by Jaffuel and Pirión (1926). However, it seems that it has never been validly published.

PHYLOGENETIC CONSIDERATIONS

Considering the groups proposed by Rozen (1951), *Liphanthus* is clearly not in the *Panurgus* group *(Panurgus, Camptopoeum, Panurginus,* and *Epimethea)* or the *Nomadopsis* group *Nomadopsis, Acamptopoeum, Hypomacrotera, Spinoliella,* and *Callonychium).* It is distinguished from them both by the general shape of genital capsule and by the associated sterna.

From *Xenopanurgus* and *Perdita* it is separated by the slender gonocoxites and comparatively small gonostyli. On the other hand, as Michener (1952) points out, *Xenopanurgus* differs from the other genera of Panurginae by numerous external morphological characters. *Perdita* also differs from *Liphanthus* by its markedly short submarginal cell and broader pterostigma.

Liphanthus was considered as a synonym of *Psaenythia* for several years.

However, the significant differences that the latter genus presents in its genitalia, such as non-articulated gonostyli with specialized hairs, peculiar penis valves and large volsellae with many small teeth, show its considerable divergence from *Liphanthus*.

Liphanthus is included in a group of genera having the alternatives to the above characters: articulated gonostyli without specialized hairs, simple penis valves, smaller vosellae with fewer teeth. These genera are *Protandrena, Metapsaenythia, Pseudopanurgus, Heterosarus,* and *Pterosarus*. Although the wing venation, and particularly the pterostigma, present important differences, the relation of *Liphanthus* to the genera listed above, and especially to *Protandrena,* seems probable. A better knowledge of the genera of Neotropical Panurginae, however, is needed to clarify relationships between *Liphanthus* and the other genera.

The plesiomorphic and apomorphic characters have been determined by comparison within the genus and with other Panurginae. The genera listed in the preceding paragraph are, together, considered as the outgroup for cladistic analysis. Their resemblances to *Liphanthus* are plesiomorphies. The characters used in the cladistic analysis of *Liphanthus* are mainly those of males. Females, in general, are uniform within this group, being plesiomorphic for most of their characters.

The apomorphies that define *Liphanthus* as a holophyletic group are: pterostigma (measured from distal end of prestigma to base of vein r) narrow, similar to prestigma in width and as long as prestigma or slightly longer (0.6:0.6, 0.9:0.7) and with subparallel sides; margin of pterostigma within marginal cell straight; basal transverse groove of metasomal tergum II (especially in males) deeper than in terga III to VII. In the outgroup the contrasting characters are: pterostigma broader than prestigma, about twice as long as prestigma or somewhat longer (0.8:0.45, 1.2:0.6, 1.15:0.5, 1.9:0.8), sides before vein r rather divergent toward apex of wing; pterostigmal margin in marginal cell convex; basal groove of metasomal tergum II as well developed as in terga III to VII.

Cladistic relationships are postulated on the basis of 26 characters listed in Table 1. Their distribution among the subgenera is shown by numbered line segments in Figure 159. Initially, 30 characters were considered, but four of them were eliminated because they may show convergence rather than synapomorphy.

One of the discarded characters was the relation between the interalveolar distance and alveolar diameter. In *Neoliphanthus, Tricholiphanthus,* and *Leptophanthus* these values are similar; therefore a relation between the three subgenera seem possible. However, as shown in Figure 159, on the basis of other characters these subgenera are well separated and this character must have arisen at least twice.

Another character, also eliminated, was the presence of a mesal projection on the posterior margin of metasomal sternum II. This is a typical character of *Neoliphanthus* and *Leptophanthus,* but also present, in a similar way, in some species of *Pseudoliphanthus* and *Tricholiphanthus*.

The diverse positions of these subgenera in Figure 159 suggest polyphyletic origin of this feature. Moreover, the projection in the last subgenus looks somewhat different and could therefore be either another variable or a modification of the first variable.

Sinuous inner orbits occur in *Leptophanthus, Neoliphanthus, Melaliphan-*

TABLE 1. List of Apomorphies for Subgenera of *Liphanthus*.

1. *Vertex concave or almost flat.* An autapomorphic character for *Xenoliphanthus*. The outgroup for *Liphanthus* and all the other Panurginae examined have the vertex convex, a character here considered as plesiomorphic.
2. *Male with lateral ocelli at same level as upper orbital tangent.* The outgroup and most of the Panurginae observed present the plesiomorphic condition, that is, male with the lateral ocelli above the upper orbital tangent.
3. *Male with first flagellar segment 2 or more times as long as broad.* This character separates the 6 remaining subgenera from *Leptophanthus* which retains the plesiomorphic alternative from the whole outgroup, that is, first flagellar segment less than twice as long as broad.
4. *Male with flagellum distinctly longer than width of head.* Only *Leptophanthus* has retained the plesiomorphic condition. *Xenoliphanthus* apparently has lost the derived condition. All the outgroup and most of the other Panurginae examined are also plesiomorphic in this character, i.e., with the first flagellar segment short and broad.
5. *Male with inner orbits divergent ventrally and not sinuous.* The outgroup presents the plesiomorphic condition, that is, inner orbits in males divergent dorsally and weakly sinuous.
6. *Male with inner orbits strongly divergent ventrally.* This is a progression of character 5. It is found in *Liphanthus s. str.* and *Pseudoliphanthus,* although in one species (*L. unifasciatus* of the later subgenus) it is not so conspicuous, being more as in *Xenoliphanthus*. The whole outgroup presents the plesiomorphic condition. *Xenoliphanthus* has its inner orbits slightly divergent ventrally (character 5).
7. *Male with outer subantennal suture strongly arcuate laterally, almost angulate.* An autapomorphic character of *Pseudoliphanthus,* although it is not so strongly curved in one of its species. The inner subantennal suture is almost straight or moderately arcuate in many bees including most Panurginae; this condition is here considered as plesiomorphic.
8. *Male with median paraocular area with transverse swelling below the level of the facial fovea.* This character is an autapomorphy for *Liphanthus s. str.* The absence of this character in the outgroup and other Panurginae is considered as plesiomorphic.
9. *Clypeus with well developed long, longitudinal median groove (as long as clypeus).* Some species of the outgroup have a groove but it is usually weak. If it is well developed, it is short and different from that of *Xenoliphanthus*. In one of the species of *Tricholiphanthus* a poorly developed groove is also present. Most bees do not have a well developed median longitudinal groove; this lack is here considered plesiomorphic.
10. *Male clypeus with upper part transversely prominent (Fig. 103), the rest flat and directed backward.* This is an autapomorphy for *Neoliphanthus*. None of the genera in the outgroup presents this character. Most bees have the whole clypeus slightly convex or more or less flattened proximally. In *Pseudoliphanthus* and *Liphanthus s. str.* there is a median proximal protuberance (character 15), but the clypeus is not transversely prominent as in *Neoliphanthus*.
11. *Male with the upper part of clypeus below the level of adjacent integument.* This is an autapomorphic for *Melaliphanthus*. Among all the genera examined, none

showed the upper area of the clypeus depressed. Therefore the condition of being at same level or somewhat above the adjacent integument seems to be plesiomorphic.

12. *Male with lower part of clypeus transversely convex, and shiny, rest of clypeus tending to be flattened.* This character seems to be synapomorphic for *Tricholiphanthus* and *Melaliphanthus,* even though it is less distinct in *L. (Tricholiphanthus) leucostomus.* The outgroup and many other bees have the distal part of the clypeus more or less convex (but not shining and distinctly transversely convex) which is considered as plesiomorphic.
13. *Upper part of clypeus in males dull.* this character appears as synapomorphic for *Melaliphanthus* and *Tricholiphanthus.* Similar integument of the clypeus is present in one species of *Pseudoliphanthus* and also in *Neoliphanthus;* however the shape of the clypeus in these last subgenera is completely different from that of the other 2 subgenera mentioned above. Probably a complex of clypeal characters is demonstrating their relationship.
14. *Male with lateral area of clypeus (ventral view) widened laterally.* Autapomorphic for *Pseudoliphanthus.* The outgroup and other Panurginae present the plesiomorphic condition, that is, clypeus with lateral area widened mesally (ventral view).
15. *Male clypeus with a rounded protuberance, more or less developed, in mid line of its upper part.* This character is synapomorphic for *Pseudoliphanthus* and *Liphanthus s. str.* In some species it looks like a part of the median ridge, but it seems to be independent of it. It is not found in the outgroups or other Panurginae examined.
16. *Male with lower paraocular area and lateral area of clypeus sloping upward to mid part of clypeus and almost at right angles to it.* This character is autapomorphic for *Leptophanthus.* Most of the genera of the outgroup and many other Panurginae have the areas mentioned above at an angle much less than 90°; this is considered plesiomorphic.
17. *Male lower face with moderately long and dense pubescence.* This feature is autapomorphic for *Tricholiphanthus.* The outgroup and most other Panurginae show very short and sparse pubescence, the plesiomorphic condition.
18. *Male with postmandibular area mesally about half or more as long as base of the mandible.* This character is autapomorphic for *Melaliphanthus.* All the other Panurginae examined have this area much shorter than the base of the mandible, a feature here considered plesiomorphic.
19. *Male with pronotum protuberant at dorso-lateral angle.* This feature is autapomorphic for *Tricholiphanthus.* The protuberant area is acuminate apically, much less conspicuous in *L. pilifrons.* In some species of the outgroup and of other Panurginae this area is carinate or a rounded, conspicuous, protuberance. However, in most of the genera the whole dorsal margin of the pronotum is slightly rounded. In no case is it angulate as in *Tricholiphanthus.*
20. *With 2 submarginal cells.* Four genera of the outgroup and most other Panurginae present this character. It also appears in *Neoliphanthus* as an autapomorphy. The presence of 3 submarginal cells is widespread in bees and wasps; therefore this appears to be the plesiomorphic condition, still retained in one of the genera of the outgroup as well as in most *Liphanthus.*
21. *Hind tibial spurs strongly curved at apices.* This feature is autapomorphic for *Xenoliphanthus.* The whole outgroup and nearly all other Panurginae examined

have these spurs almost straight or very slightly curved. Only in *Austropanurgus* and in some species of *Perdita* are the spurs apically curved as in *Xenoliphanthus*. In one genus *(Arhysosage)* the entire spurs are more distinctly curved.

22. *Male with propodeal triangle laterally less than half length of metanotum (laterally).* This character is autapomorphic for *Neoliphanthus*. The plesiomorphic condition, found in other Panurginae, seems to be the propodeal triangle laterally longer than half of the length of the metanotum (laterally). These measurements are all made parallel to the long axis of the insect's body.
23. *Male metasomal sternum III with posterior margin concave in the middle.* This character appears as a wide concavity in 2 of the species of *Tricholiphanthus,* but is distinctly reduced in the third *(L. pilifrons).* Most of the outgroup and all of the other Panurginae examined have this sternal margin almost straight or somewhat convex, no doubt the plesiomorphic condition.
24. *Male metasomal sternum IV with posterior margin concave in the middle.* This character is autapomorphic for *Tricholiphanthus.* It is more reduced (almost straight) in *L. pilifrons* than in the other species of the subgenus. Most of the outgroup and several other Panurginae present the plesiomorphic condition, that is, posterior margin of sternum IV is convex or almost straight.
25. *Pygidial plate present in male.* This may be a weak character. The plate appears clearly defined by a carina in *Xenoliphanthus* and *Liphanthus s. str.* The rest of the subgenera show this structure similar to that of the outgroup and many other Panurginae, that is a bare and shiny area forming a triangle (between the hairy sides), poorly defined, not delimited by carinae, sometimes with a median longitudinal ridge, usually not reaching the posterior margin of the tergum. The pygidial plate in males is widespread in bees and wasps. Because of its poorly developed condition in nearly all Panurginae examined, it is here described as absent when merely represented by a bare area. The presence of this plate in other bees is plesiomorphic, but for *Liphanthus* is apomorphic. Reversal is possible since the genes for this structure must be retained for the females; the plate could reappear in males merely by turning on the functioning of these genes in males. This apomorphy may have appeared in the ancestor of *Liphanthus s. str., Xenoliphanthus,* and *Pseudoliphanthus,* but has been lost in the latter subgenus (Figure 159). It would also be possible for this structure to arise twice independently in *Liphanthus s. str.* and *Xenoliphanthus;* the same number of changes (2) would be required in either case.
26. *Male metasoma with yellow bands.* This is a synapomorphy for *Liphanthus s. str.* and *Pseudoliphanthus.* This character is widespread among bees; however is not present in the outgroup or in many other Panurginae. Therefore its absence is here considered as plesiomorphic.

---

thus, and some *Tricholiphanthus,* which could indicate for them a common derivation. However, it seems that the elongation of the first flagellar segment is a meaningful apomorphic character which separates *Leptophanthus* and clearly groups the rest of the subgenera. The sinuosity is evidently a plesiomorphy and its loss is associated with the divergence below the inner orbits (characters 5, 6, which are apomorphies). A flat upper paraocular area is present in *Neoliphanthus* and *Melaliphanthus.* This character appar-

ently is also correlated with the sinuosity of the inner orbits, already discussed above, and is well marked in these two subgenera.

The cladogram (Figure 159) was prepared by hand using the methods of Hennig (1966). In addition, a computer program by J. S. Farris (1970) was used by Mr. Robert W. Brooks at the University of Kansas to prepare a cladogram (Wagner tree). The cladogram obtained using the computer was like that in Figure 159 but less parsimonious since character 2 appeared

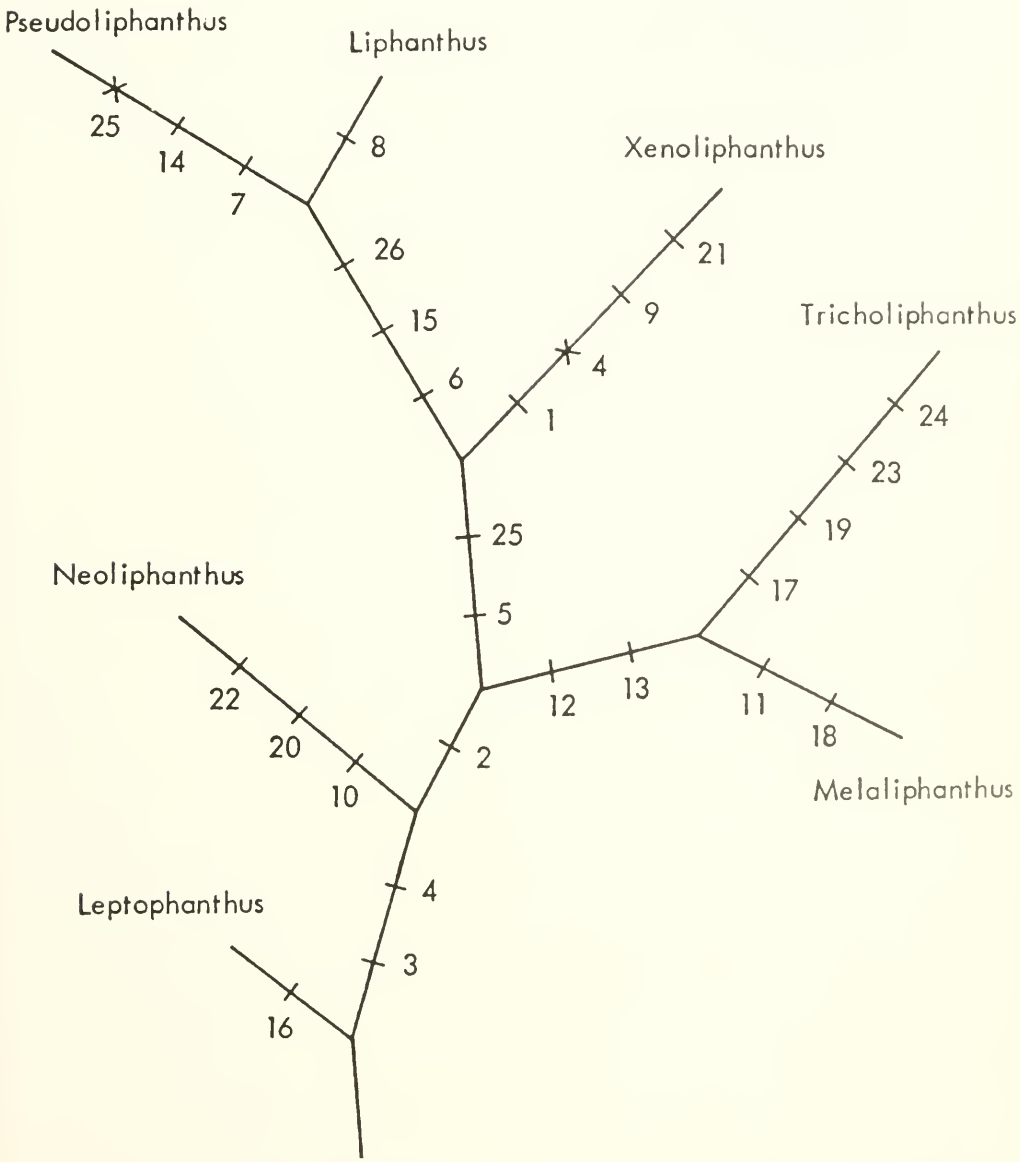


Fig. 159. Cladogram showing the cladistic relationships of the subgenera of *Liphanthus*. The lengths of the lines show the amount of change indicated by the synapomorphies and autapomorphies listed in Table 1. The angles have no meaning. X means the loss of an apomorphous character

twice, once as a reversal.

It is interesting to notice the position of *Leptophanthus* in Figure 159, since it presents numerous plesiomorphic characters. This generalized condition could be related to a broader geographic distribution, as will be indicated later.

Neoliphanthus, Tricholiphanthus, and *Melaliphanthus* are separated by a number of apomorphic characters which characterize them clearly. On the other hand, they share important plesiomorphic characters that make them phenetically highly similar. *Tricholiphanthus* and *Melaliphanthus* seem to be more closely related to each other than to *Neoliphanthus* (Figure 159).

Xenoliphanthus stands out for its distinctive autapomorphic characters, which set it phenetically apart from the rest, especially the strongly curved hind tibial spurs and the scarcely to distinctly concave (rather than convex) vertex.

Liphanthus and *Pseudoliphanthus* are separated from the rest of the subgenera by three apomorphic characters, which at the same time are conspicuous and give them a general common appearence different from the other subgenera.

DISTRIBUTION

The species of *Leptophanthus* are distributed from Atacama Province in the north to Arauco Province in the south, also crossing to Argentina (see Maps I and II). It is important to notice that this is the most diversified of the subgenera, including seven species described in the present paper.

Neoliphanthus is one of the most narrowly distributed groups, since only one species is known; it is from the precordillera of Linares Province.

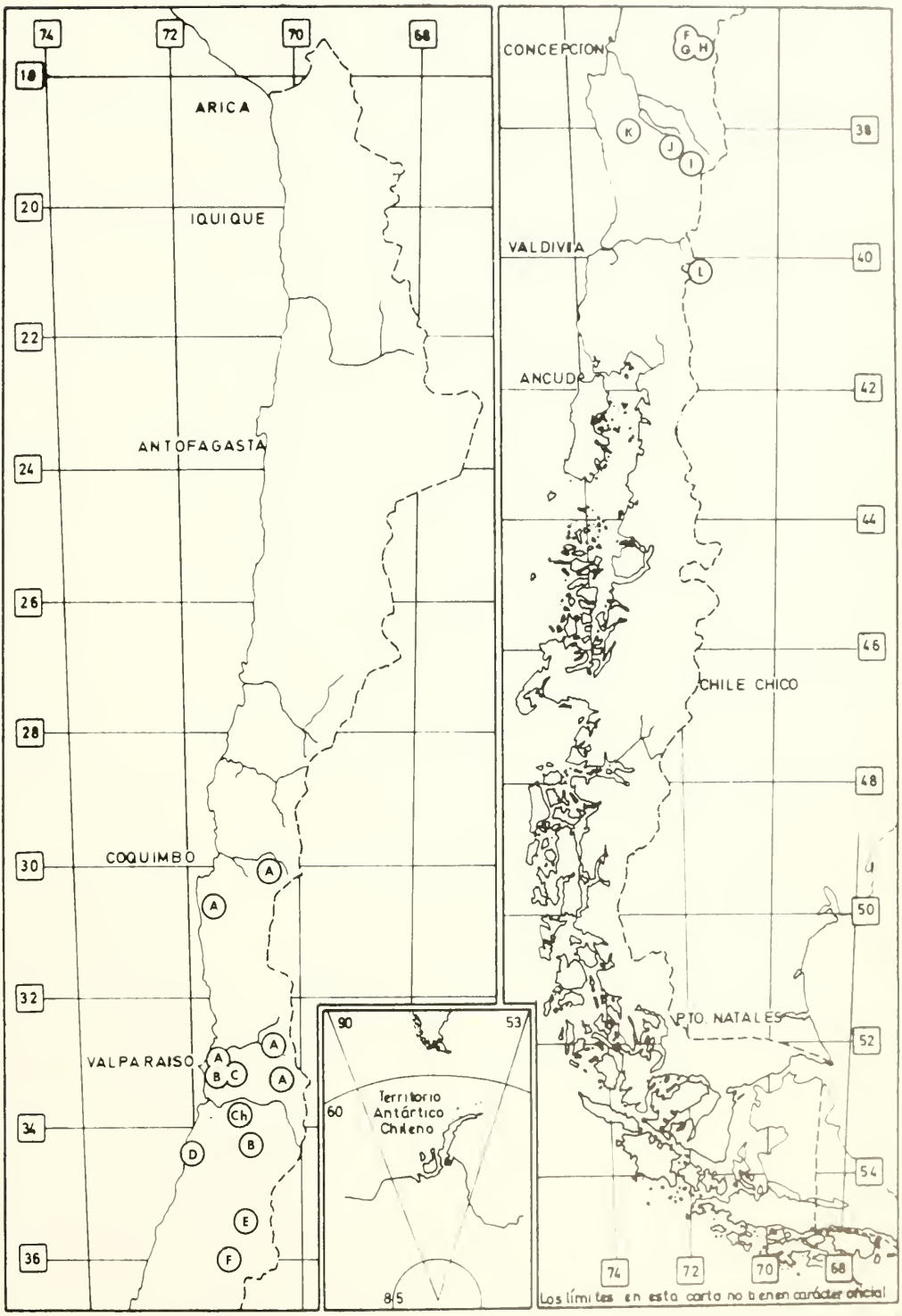
The two species of *Melaliphanthus* have been found only in the precordillera zone of Malleco Province, and like *Neoliphanthus* have a restricted geographic distribution.

Tricholiphanthus, which contains only three species, appears somewhat more diversified than the subgenera mentioned in the preceding paragraph; it is known only in Santiago and Malleco Provinces.

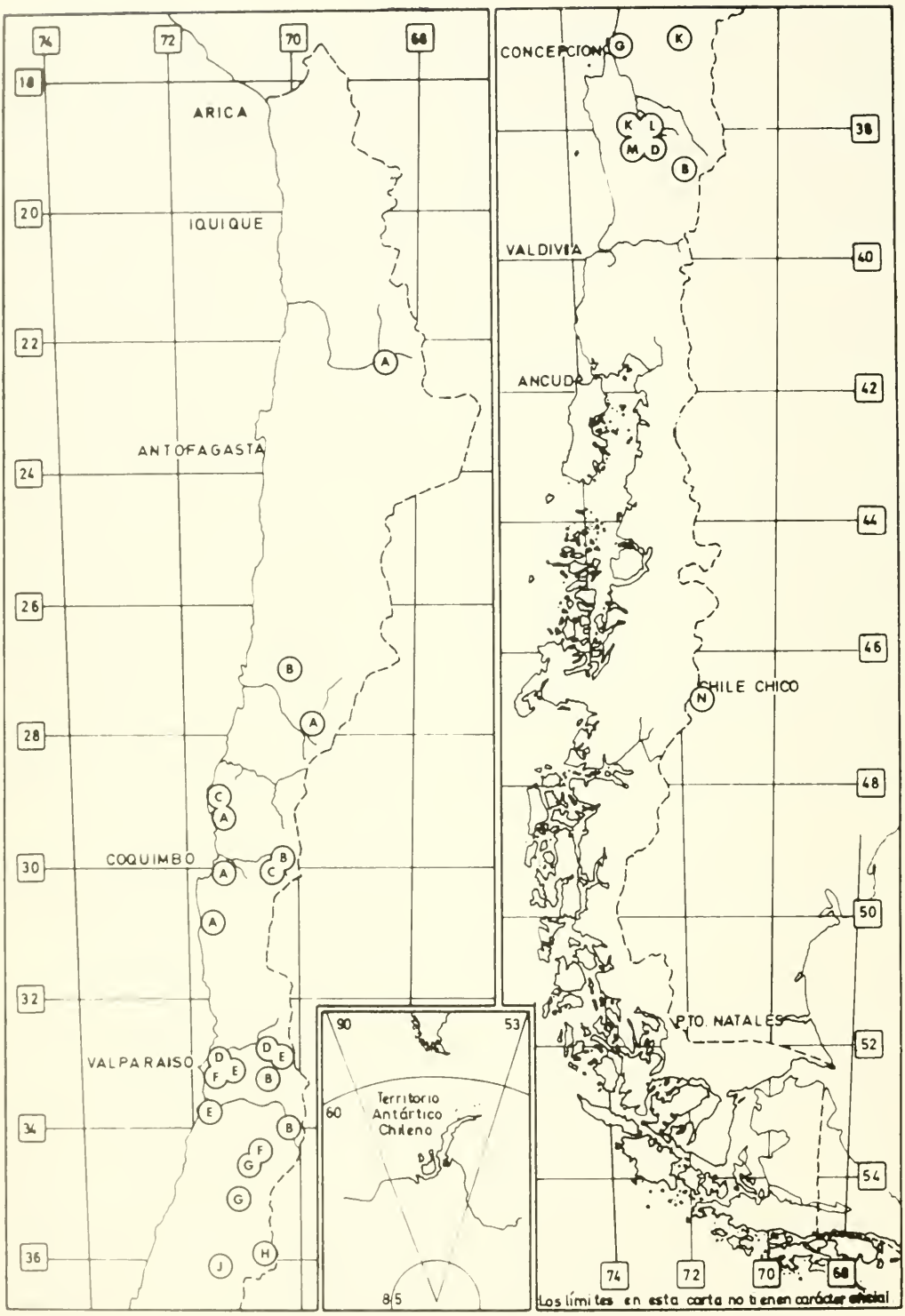
Xenoliphanthus is represented by four species broadly distributed from Coquimbo Province in the north to Arauco Province in the south. Considering the number of known species, this subgenus is restricted in distribution.

Pseudoliphanthus and *Liphanthus* are sympatric in most of their range. However, *Pseudoliphanthus* is more broadly distributed to the south, extending from Valparaíso Province to Lacar Lake in southern Argentina. On the contrary, *Liphanthus s. str.* occupies more northern areas, from Coquimbo Province to Malleco (south-central Chile).

The great number of new species described here, and the small number of specimens of some of them, suggest that more new species will be collected and that the distributions of the subgenera summarized above will be modified.



MAP I. Geographical distribution of the genus *Liphanthus*. A, *L. (Liphanthus) sabulosus* Reed; B, *L. (Liphanthus) brevicornis* n. sp.; C, *L. (Pseudoliphanthus) unifasciatus* n. sp.; Ch, *L. (Tricholiphanthus) leucostomus* n. sp., D, *L. friesellu* n. sp.; E, *L. (Pseudoliphanthus) rozeni* n. sp.; F, *L. (Liphanthus) chillanensis* n. sp.; G, *L. (Pseudoliphanthus) spinicentris* n. sp.; H, *L. (Tricholiphanthus) pilifrons* n. sp.; I, *L. (Liphanthus) barbatus* n. sp.; J, *L. (Melaliphanthus) penai* n. sp.; K, *L. (Melaliphanthus) atratus* n. sp.; L, *L. (Pseudoliphanthus) andinus* n. sp



MAP II. Geographical distribution of the genus *Liphanthus*. A, *L. (Leptophanthus) coquimbensis* n. sp.; B, *L. (Leptophanthus) alicahue* n. sp.; C, *L. (Xenoliphanthus) tofensis* n. sp.; D, *L. (Leptophanthus) breviceps* (Friese); E, *L. (Xenoliphanthus) parculus* (Friese); F, *L. (Leptophanthus) anacanthus* n. sp.; G, *L. (Leptophanthus) nitidus* n. name; H, *L. (Xenoliphanthus) moldenkei* n. sp.; J, *L. (Neoliphanthus) bicellularis* n. sp.; K, *L. (Xenoliphanthus) micheneri* n. sp.; L, *L. (Tricholiphanthus) tarsalis* n. sp.; M, *L. (Leptophanthus) cerdai* n. sp.; N, *L. (Leptophanthus) australis* n. sp.

Literature Cited

Ashmead, W. H. 1899. Classification of the bees of the superfamily Apoidea. Trans. Amer. Entomol. Soc. 26:49-100.

Claude-Joseph, F. (H. Janvier). 1926. Recherches biologiques sur les Hyménoptères du Chile (Mellifères). Ann. Sci. Nat., Zool. (10)9:113-268. (Trans. J. Herrera and M. Etcheverry. 1960. Publicaciones del Centro de Estudios Entomológicos, Santiago, no. 1:1-64.)

Cockerell, T. D. A. 1916. Descriptions and records of bees. 72. Ann. Mag. Nat. Hist. (8)17:428-435.

Ducke, A. 1912. Die natürlichen Bienengenera Südamerikas. Zool. Jahrb. Abt. f. Syst. 34:51-116.

Ehrenfeld, J. and J. G. Rozen, Jr. 1977. The cuckoo bee genus *Kelita*, its systematics, biology and larvae. Amer. Mus. Novit. 2631:1-24.

Farris, J. S. 1970. Methods for computing Wagner trees. Syst. Zool. 19:83-92.

Friese, H. 1908. Die Apidae (Blumenwespen) von Argentina nach den Reisenergebnissen der Herren A. C. Jensen-Haarup und P. Jörgensen in den Jahren 1904-1907. Flora og Fauna 10:1-94.

_____. 1916. Neue Bienen-Arten aus Chile und Sudamerika. Stettin. Ent. Ztg. 77:163-174.

Harris, R. A. 1979. A glossary of surface sculpturing. Occ. Pap. Entomol., Calif. Dept. Food Agric., Div. Plant Industry Lab. Serv. 28:1-31.

Hennig, W. 1966. Phylogenetic Systematics. Univ. Illinois Press, Urbana. 263 p.

Herbst, P. 1921. Zur Synonymie chilenischer Grabwespen. Stettin. Ent. Ztg. 82:113-116.

_____. 1922. Revision der Halictus-Arten von Chile. Ent. Mitteilungen 11:180-191.

Holmberg, E. 1921. Apidae Argentinae. Ann. Mus. Nac. Hist. Nat. Buenos Aires 30:249-454.

Jaffuel, F. and A. Pirion. 1926. Himenopteros del Valle de Marga-Marga. Rev. Chil. Hist. Nat. 30:362-383.

Michener, C. D. 1944. Comparative external morphology, phylogeny and a classification of the bees (Hymenoptera). Bull. Amer. Mus. Nat. Hist. 82:151-326.

_____. 1952. A new genus of panurgine bees from Arizona. J. Kansas Entomol. Soc. 25:24-28.

_____. 1965. Bees of the Australian and South Pacific regions. Bull. Amer. Mus. Nat. Hist. 130:1-362.

Moldenke, A. R. 1976. Evolutionary history and diversity of the bee faunas of Chile and Pacific North America. Wasmann J. Biol. 34:147-178.

Moldenke, A. R. and J. L. Neff. 1974. Studies on pollination ecology and species diversity of natural Chilean plant communities. Tech. Report 74-18, Origin and Structure of Ecosystems, IBP/IBP. Pages 1-134, Univ. California, Santa Cruz.

Reed, E. 1894. Los fosores o avispas cavadoras. Ann. Univ. Chile 85:591-653.

Rozen, J. G, Jr. 1951. A preliminary comparative study of the male genitalia of Andrenidae. J. Kansas Entomol. Soc. 24:142-150.

_____. 1967. Review of the biology of panurgine bees with observations on North American forms (Hym.-Apoidea). Amer. Mus. Novit. 2297:1-44.

_____. 1970. Biological observations on the parasitic bee *Kelita* (Hym.-Apoidea). J. New York Entomol. Soc. 78:146-147.

8124

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

MUS. COMP. ZOOL
LIBRARY
OCT 22 1985
HARVARD
UNIVERSITY

A TAXONOMIC REVISION OF THE LYGAEINAE OF AUSTRALIA (HETEROPTERA: LYGAEIDAE)

By
Alex Slater

Vol. 52, No. 9, pp. 301–481 Oct. 1, 1985
[This concludes Vol. 52]

ANNOUNCEMENT

The *University of Kansas Science Bulletin* (continuation of the *Kansas University Quarterly*) is an outlet for scholarly scientific investigations carried out at the University of Kansas or by University faculty and students. Since its inception, volumes of the *Bulletin* have been variously issued as single bound volumes, as two or three multi-paper parts or as series of individual papers. Issuance is at irregular intervals, with each volume prior to volume 50 approximately 1000 pages in length. Effective with volume 50, page size has been enlarged, reducing the length of each volume to about 750 pages.

The supply of all volumes of the *Kansas University Quarterly* is now exhausted. However, most volumes of the *University of Kansas Science Bulletin* are still available and are offered, in exchange for similar publications, to learned societies, colleges and universities and other institutions, or may be purchased at $20.00 per volume. Where some of these volumes were issued in parts, individual parts are priced at the rate of 2 cents per page. Current policy, initiated with volume 46, is to issue individual papers as published. Such separata may be purchased individually at the rate of 3 cents per page, with a minimum charge of $1.00 per separate. Subscriptions for forthcoming volumes may be entered at the rate of $20.00 per volume. All communications regarding exchanges, sales and subscriptions should be addressed to the Exchange Librarian, University of Kansas Libraries, Lawrence, Kansas 66045.

Reprints of indivudal papers for personal use by investigators are available gratis for most recent and many older issues of the *Bulletin*. Such requests should be directed to the author.

The International Standard Serial Number of this publication is US ISSN 0022-8850.

Editor
William L. Bloom

Editorial Board

Philip W. Hedrick
Rudolf Jander
Charles D. Michener
Delbert Shankel
Norman A. Slade
Henry D. Stone
George W. Byers, *Chairman*

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN
Vol. 52, No. 9, pp. 301–481 October 1, 1985

A Taxonomic Revision of the Lygaeinae of Australia (Heteroptera: Lygaeidae)

Alex Slater[1]

Department of Entomology, University of Kansas

Contents

Abstract 301
Introduction 302
Materials and Methods 304
Taxonomic Characters 305
Acknowledgements 307
Key to the Australian genera of Lygaeinae 308
Arocatus Spinola 309
Astacops Boisduval 326
Scopiastella Slater 330
Scopiastes Stål 345
Thunbergia Horváth 370
Woodwardiastes, gen. nov. 378
Aspilocoryphus Stål 381
Graptostethus Stål 385
Pyrrhobaphus Stål 398
Melanerythrus Stål 401
Melanotelus Reuter 411
Spilostethus Stål 417
Oncopeltus Stål 426
References Cited 437

Abstract

The lygaeid subfamily Lygaeinae is revised for Australia. Keys to genus and species are provided for all included taxa. Each genus and species is described or redescribed in detail. The external male and female genitalia are figured for most species. Drawings of the dorsum of many species are also provided. Thirteen genera are recognized. The genus *Woodwardiastes*, gen. nov., is described. *Scopiastella* Slater is raised from subgeneric to generic rank. *Brachylygaeus* Gross is synonymized with *Melanerythrus* Stål. A total of 63 species are recognized. Three species are removed from synonymy: *Melanotelus rubiginosus* (Walker), *Oncopeltus purpurascens* Distant, and *Spilostethus pacificus* (Boisduval). Six species are reduced to junior synonyms: *Graptostethus parcus* Distant of *Arocatus contractus* Distant, *Lygaeus singularis* Walker of *Arocatus rusticus* (Stål); and *Lygaeus castaneipes* Dallas, *Lygaeus innotatus* Dallas, *Oncopeltus sordidus* var. *castaneipes* Horváth, and *Oncopeltus consors* Distant of *Oncopeltus quadriguttatus* (Fabricius). Twenty-five new species are described: *Arocatus chiasmus*, *Arocatus fastosus*, *Arocatus montanus*, *Graptostethus pubescens*, *Graptostethus varipictus*, *Melanerythrus ignitus*, *Melanerythrus uptoni*, *Melanotelus geriae*, *Scopiastella himertos*, *Scopiastella nigricornatus*, *Scopiastella rubricinctus*, *Scopiastella woodwardi*, *Scopiastes facetus*, *Scopiastes impeditus*, *Scopiastes kurandensis*, *Scopiastes obscurus*, *Scopiastes perplexus*, *Scopiastes scudderi*, *Scopiastes taroomi*, *Scopiastes yorkensis*, *Thunbergia marcida*, *Thunbergia rufifemur*, *Thunbergia tumida*, *Woodwardiastes exilis*, and *Woodwardiastes monteithi*. A neotype is designated for *Oncopeltus quadriguttatus* (Fabricius). Parasitization of *Arocatus rusticus* (Stål) and *Oncopeltus sordidus* (Dallas) by the tachinid fly *Alophora aureiventris* Curran is reported. Some food plant records are included.

[1] James A. Slater II. Alex Slater is used to avoid confusion in the literature with the author's father, Dr. J. A. Slater.

INTRODUCTION

The subfamily Lygaeinae may be characterized by: all abdominal spiracles dorsal; sutures of abdominal venter straight or nearly so, all reaching lateral margin of abdomen; apical margin of corium straight; hemelytra impunctate; membrane of forewing with distinct basal cell; hindwing with hamus and subcosta; hindwing lacking intervannals; no m-chromosome; phallotheca with lateral processes; vesica with ring sclerite; ovipositor with extensive membranous areas; and nymphal abdominal scent glands between terga IV and V and V and VI.

Many members of the Lygaeinae are unusual among the Lygaeidae both in appearance and habitat. Where the "average" lygaeid is a small, cryptically colored ground dweller, many (if not most) lygaeines are of medium to large size, boldly patterned in red or orange and black, and are found on or in conspicuously placed plant seed pods. The association of many species with members of the plant family Asclepidaceae has earned the subfamily the common name of milkweed bugs. Many species feed on "poisonous" plants of the families Asclepidaceae, Apocyanaceae, and Solanaciae. This has led to the belief that the bright coloration is aposomatic. Scudder and Duffy (1972) reported the presence of cardiac glycosides in several genera. Avoidance by predators of brightly colored species has not yet been demonstrated.

The last major classification of the subfamily is that of Stål (1874). Slater (1964*a*) raised many of Stål's subgenera to generic level. Unfortunately, as pointed out by Slater (1964*b*) and by Ashlock (1975), Stål's reliance on color characters to define his generic level groups resulted in an identification scheme which tends to obscure the phylogenetic relationships within the subfamily. As a result the generic classification of the Lygaeinae is in need of a complete revision. In this paper I am fairly conservative in the use of generic names, preferring to await study of species from other areas before suggesting major changes in classification.

As a result of their size, coloration, and habitat the Lygaeinae received more attention from early entomologists than did the majority of lygaeids. The first members of the subfamily to be described from Australia were *Melanerythrus biguttatus* and *Oncopeltus quadriguttatus*. Both species were described in the genus *Cimex* by Fabricius (1775) from material in the Banks Collection. A total of 40 additional species were described by Gmelin (1790), Boisduval (1835), Erichson (1842), Dallas (1852), Stål (1865, 1867, 1874), Walker (1872), Breddin (1900), Distant (1901*a*, 1918), and Horváth (1902, 1914). Of these 40 species 25 are still considered distinct. Following Distant's 1918 paper no new species were described from Australia until Scudder (1963) in his revision of the "*Astacops* complex" described five species as new. The addition of six species described from other parts of the world but occurring in Australia and 25 species described as new in this paper brings the total for the continent to 63.

Slater (1964*a*) listed 39 genera and 414 species in the Lygaeinae. Two genera, *Lygaeus* and *Oncopeltus,* are distributed worldwide. The greatest diversity in both genera and species occurs in the tropics of both hemispheres. The Australian fauna consists of 63 species in 13 genera. This is roughly comparable to the 32 species in 14 genera from South Africa, 35 species in six genera from North America north of Mexico, and 41 species in 12 genera from the Palearctic reported by Slater (1964*b*).

The tropical element present in the Australian fauna and largely absent in the other areas accounts for the greater number of species in Australia.

The Australian fauna exhibits a high degree of endemism at the species level and virtually no endemism at the genus level. Of the 63 known species 51 are endemic while only one of the 13 known genera is restricted to the continent. The chaotic state of the higher classification of the subfamily makes a detailed analysis of the Australian fauna impossible. However, a few general statements may be made. Only one genus found in Australia has a worldwide distribution. This is *Oncopeltus* which is widespread in both hemispheres with the majority of its species in the tropics. A group of genera including *Arocatus, Aspilocoryphus, Graptostethus, Melanotelus,* and *Spilostethus* is widespread in the eastern hemisphere. *Pyrrhobaphus* is primarily Oriental and Pacific in distribution. *Melanerythrus* is centered in Australia with one species recorded from Fiji and Timor and another species from New Guinea and Timor. A final group including the genera *Astacops, Scopiastella, Scopiastes,* and *Thunbergia* reaches maximum diversity in Australia, New Guinea, and the Wallacian region with some species in the Oriental and Pacific regions. *Woodwardiastes,* the only strictly endemic Australian genus, also belongs to this group.

At the specific level one species, *Graptostethus servus* (Fabricius), is widespread in the eastern hemisphere. Two species, *Spilostethus hospes* (Fabricius) and *Pyrrhobaphus leucurus* (Fabricius), are widespread in the Oriental and Pacific regions. *Arocatus continctus* Distant displays a curious disjunct distribution, being found in western Africa, India, and Australia. The remaining extralimital species are shared with New Guinea and/or the Wallacian region with the single exception of *Arocatus rusticus* (Stål) which is found on Lord Howe Island, Norfolk Island, and in New Zealand.

Within Australia the most interesting genera geographically are *Melanerythrus, Scopiastella,* and *Scopiastes. Melanerythrus* contains five species, all primarily or entirely Australian in distribution. Of the five, three (two micropters and an extremely vagile macropter) are Eyrean, one micropter is restricted to high altitudes in southeastern Australia, and one macropterous species is Torresian in Australia and also found in New Guinea and Timor. The other two genera are Torresian in their Australian distribution. Most species are associated with rainforest. Both genera show evidence of recent speciation in the presence of several closely related pairs of species where one species is northern and the other southern in distribution.

Despite their high visibility little is known about the life history and biology of the Australian Lygaeinae. Food plant records are very scarce, especially for the "*Astacops* complex" which comprises about half the fauna. The subfamily does not appear to be of economic importance in Australia despite reports of *Oncopeltus sordidus* (Dallas) on cotton in New South Wales and of *Graptostethus servus* (Fabricius) on various crops in northern and western Australia. Label data for the type series of *Scopiastes perplexus,* sp. nov., indicates them as "playing havoc among potato plants" and a series of *Melanerythrus biguttatus* (Fabricius) was taken on maize and on "Graminae" in northern Queensland. This may indicate potential for at least local damage to food crops.

An interesting aspect of lygaeine biology is an apparent fondness for nec-

tar. Many specimens of several genera have been collected on eucalyptus flowers by Dr. E. M. Exley and her assistants. It does not seem likely that they were feeding on other parts of the trees. Other records are from the flowers of various rainforest vines and the flowers of milkweed plants (*Gomphocarpus* sp.). *Graptostethus varipictus,* sp. nov., was collected on roses in northern Queensland by R. I. Storey.

Materials and Methods

Specimens were examined from the following collections: Australian Museum (AM), Australian National Insect Collection (ANIC), University of Queensland (UQ), Queensland Museum (QM), Musée d'Histoire Naturelle de la Hongrie (Budapest), British Museum (Natural History) (BMNH), Naturhistoriska Riksmuseet (Stockholm), Institut für Pflanzenschutzforschung, Abteilung Taxonomie der Insekten (Berlin), Department of Primary Industries, Queensland (DPI), West Australian Museum (WAM), South Australian Museum (SAM), New South Wales Department of Agriculture (NSWDA), Tasmanian Museum (TM), National Museum of Victoria (NMV), and Bernice P. Bishop Museum (Bishop).

Only general data on distribution are given in this paper. Complete information on label data and depository for all specimens examined is available from the author. Complete label data is supplied for all holotypes and for paratypes of newly described species.

Complete synonymies are not provided for either genera or species. Original descriptions, alternate names to which the species have been referred in the literature, and references to the locations of the taxa in Slater's (1964*a*) catalogue are given for all taxa. Papers of nomenclatoral or biological significance published since 1964 are also included.

As many of the taxa treated here are not common in collections, and were described at a time when a 12-line description was generally considered more than adequate, fairly detailed descriptions are included for both genera and species. To avoid repetition those characteristics common to all species within a genus are included in the generic description. As both generic and species descriptions are based on Australian species, they should be applied to extralimital specimens only with great caution.

Measurements were made with an ocular micrometer in a binocular dissecting microscope. Unless otherwise indicated ten specimens of each sex were measured. All measurements are given in millimeters with the mean of each measurement followed in parentheses by the range. In some cases, where very few specimens were available, measurements for all specimens examined are included. All measurements except those of the antennae and labium were made with the hemelytra parallel to the plane of focus of the microscope. Where the head or pronotum could not be completely in focus at one setting, focus was taken at the midpoint between the two extremes. As the head is often differently exserted on different specimens, this method results in considerable variation in measurements of head length. Much less manipulation of the specimen is required than with other methods and a good idea of the general shape of the insect is conveyed. This is especially true where both head and pronotum are declivent. Measurements of head and pronotal length made with the plane of focus parallel to their longest dimensions would give the impression

of a longer structure than appearance of the whole insect conveys.

Both male and female genitalia were removed from the insects after they were relaxed in a solution modified from the formula for Barber's Fluid by substituting toluene for benzene. The genitalia were grasped with watchmakers' forceps and pulled free of the abdomen. They were then soaked in concentrated "Dekon 90," a liquid surfactant used to clean laboratory glassware, for from ten minutes to overnight before being transferred to distilled water for further dissection. Muscles and fatty tissue were removed from female genitalia using watchmakers' forceps, probes made from minuten pins, and a fine sablehair brush. The two valves were separated by gently pulling with watchmakers' forceps. The aedeagus of the male was inflated using Ashlock's (1957) osmotic method substituting "Dekon 90" for potassium hydroxide. It was found that the delicate membranes of the lygaeine aedeagus were less likely to break with this change.

Drawings of genitalia were made with the aid of a squared grid in a binocular dissecting microscope. The pygophore was oriented so that the anterior opening was perpendicular to the microscope's plane of focus. Claspers were drawn from three angles, posterior and interolateral views with the opening at the base of the clasper perpendicular to the plane of focus and dorsal view with the basal opening parallel to the plane of focus. Complete ovipositor valves were prepared for drawing by tearing the membrane connecting the valvifers only and then spreading and flattening the ovipositor, resulting in an approximately lateral view of valvifers and valvulae and a ventral view of the membrane connecting the valvulae and the median sclerite. Ovipositor valves were pinned to a wax-bottomed dissecting dish with minuten pins and small parts of the male genitalia supported on cotton wool immersed in glycerine in an excavated block. The excavated block allows a modified form of dark field illumination obtained by shining a microscope light through the side of the block. This is very helpful in observing hairs and sculpture on smaller parts of the genitalia.

Dorsal views of entire insects were made either with the aid of a squared grid or a camera lucida. A scale line equivalent to one millimeter is included with each dorsal view.

Taxonomic Characters

Until now the identification of Lygaeinae has been based primarily on their color pattern. This approach has been reasonably successful in species identification as many species, even those with wide geographic ranges, have very consistent color patterns. However, other species are very variable in coloration and many structurally distinct species are very similarly patterned. There is some indication that the coloration of some species is affected by environmental factors. Specimens of *Spilostethus hospes* (Fabricius) from northern and central Australia resemble specimens from southern India while those from southeastern Queensland and New South Wales resemble specimens from Pakistan. Specimens from hotter and/or drier areas are lighter colored than those from damper and/or cooler areas.

In this paper I have tried to include both color and structure in keys to genera and species. Color characters are often easier to see and to explain while structural characters are generally more reliable. In case of doubt reference should be made to the figures

of male and female genitalia as these structures are definitive at species level. The keys, as with the descriptions, are based on Australian specimens only and should be used cautiously if at all on extralimital specimens.

Such structural characters as the relative lengths of antennal or labial segments, degree of development of the ostiolar peritreme, shape of head, punctation and shape of pronotum, and type and location of pubescence are useful in identification at both genus and species level. In addition to these characters I have found the structure of both male and female genitalia to be of great use in identification of species and in delimitation of higher categories.

The aedeagus is most useful at generic level. Such features as the apical process of the secondary gonopore, development of the ring sclerite, and presence and shape of conjunctival and vesical lobes are usually consistent within a genus. The general shape of the ejaculatory reservoir and phallothecal processes remains constant within a genus while details of their structure vary between species.

The claspers are perhaps the best means of confirming the identity of a male specimen. They are almost always unique to a species though the differences between species are sometimes hard to describe or draw. Ideally, direct comparison between claspers should be used when dealing with closely related species. In light of the difficulties in portraying the true shape of the claspers I have tried to avoid using them in the keys. I have attempted to show their shape by drawing each one from three different angles, the three angles related to one another by rotation of the clasper in one plane or another.

The pygophore is generally similar within a genus, with structural details of the areas around the dorsal opening frequently varying from species to species. The shape of the lateral margins of this opening and the median projection of the posterior margin provide especially useful characters. The shapes of these areas are often correlated with the structure of the claspers and the phallothecal processes.

The female genitalia have been little used in the identification of Lygaeidae in general. For the most part only broad surveys of higher taxa have included information on their appearance, though Scudder (1963, 1965) used the spermatheca at both generic and specific levels. I found them to be of great taxonomic value in this study. The spermatheca especially provides excellent generic and often specific characters. Within the genus *Scopiastes* the structure of the spermatheca was very useful in determining relationships of several very similarly colored species and first led me to suspect that there might be a series of north-south species pairs in the genus.

The ovipositor was also very useful taxonomically at both genus and species level. The general shape of the ovipositor and the shape and development of the median sclerite of the membrane connecting the first valvulae is for the most part consistent within genera. The exact shape of the valvifers and valvulae and details of the shape of the median sclerite often vary between species. The shape of the apex of the second valvula was found to be an especially good character at the species level. In the difficult genera *Scopiastes* and *Scopiastella* this structure is sometimes of better diagnostic value than the claspers.

In addition to their value in identification of genera and species I believe that the external genitalia will be of

great value in understanding phylogenetic relationships among the Lygaeinae of the world.

Scudder & Duffy (1972) reported the presence of a series of glands opening dorsolaterally on the mesothorax, metathorax and abdominal sterna II through VII of 28 lygaeine species belonging to several genera. In the new world species *Oncopeltus fasciatus, O. sandarachatus* and *Lygaeus kalmii* the secretions of these glands were shown to contain higher concentrations of cardenolides than did the hemolymph. As species in some genera they examined did not possess these glands the characteristic should prove useful in phylogenetic studies. The gland openings are most easily seen in specimens macerated in potassium hydroxide. Those of the abdominal sterna, which appear as short curved scars at the anterolateral angles, are often visible on untreated specimens. In this paper the presence or absence of these dorsolateral glands is noted in that part of each generic description concerned with the abdominal sterna.

Acknowledgments

This work was financed by a grant from the Australian Biological Survey to Dr. T. E. Woodward, Department of Entomology, University of Queensland.

I am indebted to the authorities of the following institutions who willingly lent specimens, many of them types: Australian Museum, Sydney; Australian National Insect Collection, Canberra; Bernice P. Bishop Museum, Honolulu; British Museum (Natural History), London; Department of Primary Industries, Brisbane; Institut für Pflanzenschutzforschung, Abteilung Taxonomie der Insekten, Berlin; Musée d'Histoire Naturelle de la Hongrie, Budapest; National Museum of Victoria, Melbourne; Naturhistoriska Riksmuseet, Stockholm; New South Wales Department of Agriculture, Sydney; Queensland Museum, Brisbane; South Australian Museum, Adelaide; Tasmanian Museum, Hobart; University of Queensland, Brisbane; and West Australian Museum, Perth.

I am especially indebted to Mr. W. D. Dolling of the British Museum (Natural History) for providing excellent color slides of many of the type specimens in that collection. Special thanks also to the members of the Department of Entomology, University of Queensland, who made my stay in Australia so pleasurable.

Brian Cantrell of DPI kindly identified the tachinid fly *Alophora aureiventris* Curran. Food plants were identified by the staff of the Queensland Herbarium with the exception of *Craspedia macrocephala* which was identified through the help of M. S. Upton of CSIRO, Canberra.

Dr. P. D. Ashlock, Department of Entomology, University of Kansas, and Dr. T. E. Woodward, Department of Entomology, University of Queensland, read the entire manuscript and provided helpful comments. Parts of the manuscript were read and commented on by Drs. G. W. Byers and C. D. Michener, University of Kansas.

For the fine dorsal views of many of the species I thank J. Hartshoorn, J. E. McDonald, S. R. Monteith, G. T. Thompson, and G. Yeo.

My very special thanks go to Dr. T. E. Woodward for giving me the chance to work on the Australian Lygaeinae and for his help and encouragement throughout the project.

Lastly but by no means least I would like to thank my wife Geri for compiling distribution data and making the distribution maps and for her support

and encouragement throughout the project.

KEY TO THE AUSTRALIAN GENERA OF LYGAEINAE

1. Eyes carried on distinct stalks . . 2
1′. Eyes not stalked, at most head swollen behind eyes 5
2. Posterior pronotal lobe with at most a few scattered punctures . . 3
2′. Posterior pronotal lobe at least moderately strongly punctate . . . 4
3. Posterior pronotal lobe shiny; head across eyes much narrower than pronotum at posterior margin . . . . . *Astacops* Boisduval
3′. Posterior pronotal lobe dull except shiny posterior and lateral margins; head across eyes about equal in width to pronotum at posterior margin *Scopiastella* Slater
4. Antennal segment I elongate, at least 1/3 as long as width of head across eyes; bucculae acutely angulate anteriorly . . . . . *Woodwardiastes,* gen. nov.
4′. Antennal segment I at most 1/4 as long as width of head across eyes; bucculae usually rounded, at most obtusely angulate anteriorly . . . . . *Scopiastes* Stål
5. Scutellum tumid, at most with a distinct longitudinal median carina 6
5′. Scutellum not tumid, with a T-shaped median carina and well defined lateral foveae 7
6. Posterior margin of pronotum produced caudad on either side of scutellum; lateral pronotal margins covered with long, stout hairs . . . . . *Oncopeltus* Stål
6′. Posterior pronotal margin nearly straight, not produced caudad to either side of scutellum; pronotum laterally without long, straight hairs . . . . . *Melanerythrus* Stål
7. Lateral scutellar foveae composed of several confluent punctures 8
7′. Lateral scutellar foveae not composed of confluent punctures, floor of foveae smooth or with transverse striations 9
8. Profemora of both sexes with a stout subapical spine; antennal segment IV much longer than II . . . . . *Thunbergia* Horváth
8′. Profemora unarmed; antennal segment IV at most slightly longer than II . . . . *Arocatus* Spinola
9. Metathoracic scent gland opening auriculate (ostiolar peritreme considerably raised above surrounding pleural surface) 10
9′. Metathoracic scent gland opening not auriculate (ostiolar peritreme scarcely differentiated from surrounding pleural surface) . . . . . *Spilostethus* Stål
10. Clavus and corium covered with long upright hairs strongly curved apically . . . . . *Melanotelus* Reuter
10′. Clavus and corium usually without long upright hairs, if such hairs present then slightly and evenly curved from base to apex 11
11. Labial segment III extending beyond metacoxae; pronotum black except lateral margins behind calli . . . . . *Pyrrhobaphus* Stål
11′. Labial segment III not extending beyond metacoxae (labial segment IV sometimes extending that far); midline of pronotum behind calli red or orange 12
12. Membrane of forewing with a white discal macula; para- and mediotergites of abdominal segments II to VI distinct . . . . . *Aspilocoryphus* Stål
12′. Membrane of forewing without discal macula; para- and

mediotergites of abdominal segments II to VI fused . . . . . *Graptostethus* Stål

Arocatus Spinola

Arocatus Spinola, 1837:257; Slater, 1964*a*:18-19; Slater and Sperry, 1973:130; Hamid and Meher, 1973*a*:36.

Tetralaccus Fieber, 1860-1861:44, 164.

Xerophagius Kiritshenko, 1950:350.

Type-species *Lygaeus melanocephalus* Fabricius 1798, monobasic.

Diagnosis.—Antennal segment IV not or but slightly longer than II; eye separated from anterior pronotal angle; head swollen behind eye; paratergites II to VI distinct; female paratergite VII fused with mediotergite; male paratergite VII fused with laterotergite; femora unarmed.

The only Australian Lygaeinae with which *Arocatus* might be confused are *Thunbergia, Astacops, Scopiastes, Scopiastella,* and *Woodwardiastes.* It differs from the first by lacking a subapical spine on the fore femur and from the latter four by not having distinctly stalked eyes.

Hamid and Meher (1973*a*) credit the genus with 24 species of which 19 are from the Palearctic region and only two from Australia. Slater and Sperry (1973) consider it to be composed of 14 species, nine with a Palearctic distribution. In this paper six Australian species are recognized. Four of these species are apparently endemic, one is also found in New Zealand and Lord Howe and Norfolk islands, and one has a curious disjunct distribution, occurring in western Africa and India as well as Australia.

As presently constituted *Arocatus* is a rather heterogenous group. In most lygaeine genera such characters as the extent and placement of granulate dull areas, the shape of the abdominal tergites, and the basic appearance of the genitalia of both sexes are constant. This is not the case in *Arocatus.*

The Australian members of the genus vary in these and other characters. The six species may be split into four groups primarily based on genitalic differences. Tables I and II illustrate the differences and interrelationships between the groups through an analysis of the distribution of 28 characters. These characters were taken from Australian species within the groups. The list is biased towards differences rather than similarities between groups and may give the impression that they are less similar in appearance than is in fact the case. As three of the groups are represented by only one species some of the character states may be of only specific value. Despite these limitations I believe that at least the large difference between the combined groups I and II on the one hand and III and IV on the other indicate two distinct lines of evolutionary development.

Group I contains *A. rusticus* (Stål), *A. aenescens* Stål, *A. chiasmus,* sp. nov., and an undescribed species from New Caledonia which is very similar to *rusticus* and *chiasmus* in general appearance. Group II contains *A. fastosus,* sp. nov., and at least one undescribed species from New Guinea. Group III contains *A. montanus,* sp. nov., a very similar undescribed species from New Guinea, and probably *A. rubromarginatus* (Distant) from New Caledonia. Group IV contains *A. contínctus* Distant and a species from the Ryukyu Islands tentatively identified as *A. fasciatus* Jakovlev.

I have examined males of five *Arocatus* species from Africa and the Palearctic and find that they are most similar to group III. However there is considerable variation in many characters. As

TABLE I. Distribution of selected characters in species groups within the Australian members of *Arocatus* Spinola.

Character	Group I	II	III	IV
Dull pronotal area extending onto posterior lobe	−	−	+	+
Median projection of pygophore short and narrow	−	−	+	+
Median projection of pygophore with a tablike process	+	+	−	−
Membrane connecting first valvulae of ovipositor with median and sublateral sclerites	+	+	−	−
First valvulae reaching apex of connecting membrane	−	−	+	+
Conjunctiva with subapical dorsal lobe	+	+	−	−
Secondary gonopore flared	+	+	−	−
Membrane connecting second valvulae of ovipositor cleft medially	+	+	−	−
Blade of clasper narrow, rounded in cross section	+	+	−	−
Posterolateral metapleural angle distinctly produced	−	−	−	+
Posterior margin of abdominal sternum II convex laterally	+	+	+	−
Vesica greatly expanded laterally at ring sclerite	−	−	−	+
Vesica forming a cup distally into which retracted gonoporal process fits	+	+	+	−
Spermatheca tightly coiled just basal to apical bulb	−	−	−	+
Gonoporal process coiled when aedeagus inflated	+	+	+*	−
Length scutellum compared to length claval commissure	1.25	1.25	2.5	2.0
First valvulae notched subapically	+	+	−**	−***
Labium reaching at least to metacoxae	+	+	−	+
Dorsal opening of pygophore with depressed "shelf" on lateral margins	−	−	+	−
Head less than half as long as wide	−	−	+	−
Posterior margin of pygophore evenly convex or nearly so	−	+	+	+
Gonoporal process constricted subapically	+	−	−	−
Tergum IX of male impressed medially	+	−	−	−
Tergum IX of male distinct from surrounding membrane	+	−	+	+
Meso- and metapleura punctate	+	−	+	+
Median hypandrial projection deeply excavated apically	−	+	−	−
Median length female abdominal sternum VI compared to lateral length	2/3	1/3	1/6	1/6

TABLE I. (Continued.)

Character	Group I	II	III	IV
Caudolateral lobe of clasper present	+ −	−	+ +	+

+ = character as stated. + + = character very strongly developed.
+ − = character much reduced. − = character not as stated.
* longer and more tightly coiled than in groups II and III.
** unmodified.
*** produced.

TABLE II. Analysis of character distribution in species groups within the Australian members of *Arocatus* Spinola.

	Group	I	II	III	IV	
	I	5 28	20	8	6	
Number of characters restricted to	II	12	5 28	8	6	Number of characters shared by
	III	0	0	7 28	16	
	IV	0	0	10	9 28	

females were not available for these species and as a detailed study of extra-Australian species is beyond the scope of this revision I have not attempted to formalize any phylogenetic conclusions based on analysis of the Australian species.

Redescription.—Structure: Moderately elongate, parallel sided. Thoracic venter, extreme base of scutellum and often pronotum anteriorly finely granulate giving a dull appearance. Entire head and body usually with interspersed semidecumbent, moderately long and longer upright hairs, the latter shortest on head, posterior pronotal lobe, and hemelytra, longest on venter. Head scarcely to moderately declivent, vertex nearly flat, produced laterally and at least slightly swollen behind eye; ocelli closer to eyes than to each other, about level with vertex; eye removed from anterior pronotal angle, directed slightly dorsolaterally; bucculae slightly to moderately produced ventrally, at least slightly convex, not reaching anterior prosternal margin. Antennal segment I surpassing anteclypeus by less than half its length, segment II or IV longest. Labial segment I thickest, each succeeding segment slightly thinner than that preceeding it. Pronotum subquadrate; narrower anteriorly; punctate except callus and extreme base; impressed and constricted behind callus; anterior margin concave; posterior margin convex; lateral margin slightly convex anteriorly, directed anteromedially and nearly straight posteriorly; posterior margin obliquely impressed lateral to scutellum; median carina at most faintly indicated behind callus; callus

moderately swollen, slightly oblique, reaching or almost reaching lateral margin at anterior angle; callar impression oblique, sinuate, unbranched. Scutellum wider than long (occasionally very slightly); bluntly acute apically; T-shaped carina present; lateral fovea deeply, coarsely punctate. Hemelytra not completely covering laterotergites except apically; costal margin nearly straight basally, slightly convex and produced on apical half; veins prominent; membrane surpassing tip of abdomen. Prosternum coarsely punctate, anterior margin slightly raised. Meso- and metasterna impunctate, posterior margins raised, mesosternum broadly, shallowly sulcate medially. Propleuron punctate. Mesopleuron at least moderately punctate. Metapleuron at least moderately punctate; ostiolar peritreme well developed; posterolateral angle not or slightly produced posteriorly; posterior margin straight or slightly concave, usually directed dorsoventrally, parallel to posterior mesopleural margin. Abdominal sterna without dorsolateral scent gland openings; II not covered by metapleuron; VI of female shorter medially than laterally; VII of female cleft to base, slightly concave laterally; VII of male concave. Abdominal terga with paratergites III to VI distinct, VII of male fused with laterotergites, VII of female fused with mediotergite; apodemes on paratergites when present. Pygophore subcircular in cross section; median projection present. Clasper variable. Aedeagus with moderately heavily pigmented phallotheca; phallothecal process curved, slightly produced dorsad; conjunctiva elongate, tubular; ejaculatory reservoir complete, Y-shaped basal projection present; vesica basally moderately long, twisted, without lobes; ring sclerite elongate, incomplete; vesica distally at least slightly flattened, slightly produced laterally, coiled, often forming cuplike receptacle for retracted gonoporal process; gonoporal process at least partly covered by visible membrane; secondary gonopore flared or oblique, without apical process. Ovipositor laciniate, variously modified. Spermatheca with pigmented apical bulb and tube distad of sperm pump; sperm pump and basal tube unpigmented.

Key to the Australian Species of Arocatus

1. Meso- and metapleura at most indistinctly punctate; costal margin of corium orange . . . . . *fastosus,* sp. nov.
1′. Meso- and metapleura distinctly punctate; at least center of costal corial margin black or brown 2
2. Labium not exceeding mesocoxae; hemelytra nearly unicolored; anterior pronotal lobe reddish orange . . *montanus,* sp. nov.
2′. Labium extending at least to metacoxae; if hemelytra unicolored then anterior pronotal lobe brown or blackish brown . . . 3
3. Scutellum about twice as long as claval commissure; anterior pronotal lobe dark brown to black; posterior pronotal lobe orange medially and on lateral margins . . . . . *continctus* Distant
3′. Scutellum about 1¼ times as long as claval commissure; if anterior pronotal lobe brown then posterior lobe also brown 4
4. Pronotum and hemelytra unicolored (brown). . . . . *aenescens* Stål
4′. Anterior pronotal lobe reddish orange; posterior lobe dark brown to black 5
5. Labium reaching abdominal sternum IV; thoracic pleura completely orange . . . *rusticus* (Stål)

5'. Labium reaching only abdominal sternum III; thoracic pleura almost completely brown . . . . . *chiasmus,* sp. nov.

Arocatus fastosus, *sp. nov.*

Figures 1; 7a; 46c; 47g, h; 48k, l; 49h, i; 50j-l; 51f; 52c, d; 53j.

Types.—Holotype ♀, "Heathlands, Y-junction, Cape York Peninsula, N. Qld., 5/12-II-1976. G.B. Monteith." in QM. *Paratypes:* 1♂, 2♀, same data as holotype, in UQ; 1♀, "Lockerbie area, Cape York, N. Qld., 13/27-IV-1973, G.B. Monteith." in UQ.

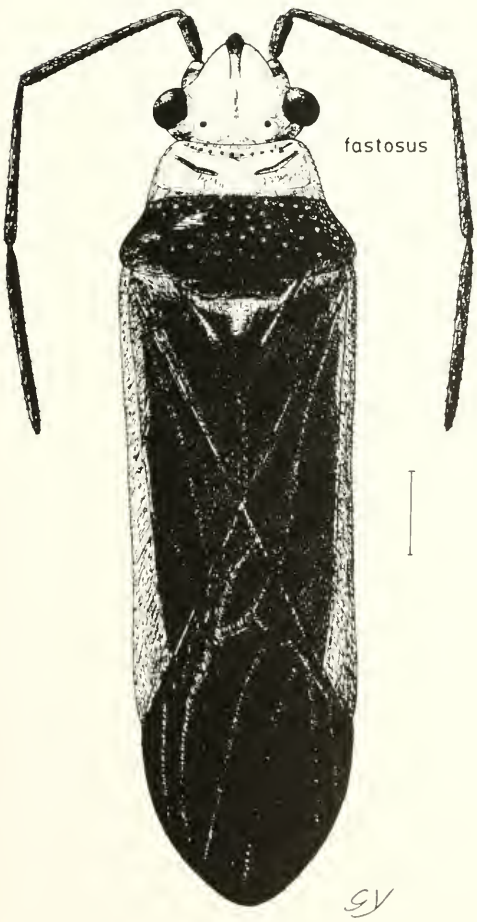


FIG. 1. *Arocatus fastosus,* sp. nov., dorsal view. Scale = 1 mm.

Description.—Color: Orange, hemelytra and abdominal venter medially darkest. The following dark brown with brilliant greenish iridescence: posterior pronotal lobe except posterior margin; apex and fovea of scutellum; clavus except base; corium except base and broad costal margin; and hemelytral membrane. The following dark brown to black: prosternum laterally; thoracic pleura except acetabulae, lateral and posterior margins of pro- and mesopleura; ostiolar peritreme; antenna; and labium. Legs except coxae light brown. Eye brown. Ocellus red. Abdominal venter mediolaterally and mesosternum laterally sometimes suffused with brown. Hemelytral membrane except base subhyaline brown, becoming paler apically.

Structure: Elongate, narrow, flattened posteriorly. Hairs shorter than in other members of the genus, longer upright hairs almost absent except on callus where short semidecumbent hairs absent. Head scarcely declivent, moderately swollen behind eye; posterior margin of ocellus about level with that of eye; buccula moderately produced, convex anteriorly, very low, slightly concave posteriorly. Antennal segment I surpassing anteclypeus by about ¼ its length. Labial segment I slightly surpassing anterior prosternal margin, II slightly surpassing procoxa, III reaching middle of metacoxa, IV reaching slightly beyond middle of abdominal sternum III. Pronotum shallowly punctate, anterior lobe including callus finely granulate giving a dull appearance. Scutellum about 1¼ times as long as claval commissure, subacute apically. Propleuron coarsely, shallowly punctate anteriorly and posteriorly, impunctate centrally. Mesopleuron shallowly punctate posteriorly, impunctate anteriorly. Metapleuron impunctate; posterior margin slightly

concave, directed dorsoventrally; posterolateral angle not produced. Abdominal sternum II with posterior margin convex laterally; VI of female about 1/3 as long medially as laterally. Abdominal dorsum as in Fig. 46c; mediotergites IV and V elongate and narrowed to their common margin. Pygophore as in Figs. 47g, h; convex posteriorly; median projection concave apically, tablike apical process present; tergum IX indistinctly separated from surrounding membrane, not impressed medially. Clasper as in Figs. 50j-l; no caudolateral lobe; blade rounded in cross section, curved and twisted; shank very shallowly excavated. Aedeagus similar to *A. rusticus* (Fig. 49e) but smaller in relation to body size; phallotheca and phallothecal process as in Figs. 48k, l; ejaculatory reservoir as in Figs. 49h, i; ring sclerite elongate, strongly convex basally; gonoporal process not strongly constricted subapically; secondary gonopore slightly flared, slightly oblique. Ovipositor as in Figs. 52c, d, 53j; membrane of first valve shallowly notched medially. Spermatheca as in Fig. 51f; sperm pump very near base.

Measurements: Holotype ♀. Length 11.0; abdominal width 3.1; head length 1.44; width across eyes 2.20; pronotal length 1.66; pronotal width 3.00; scutellar length 1.68; scutellar width 1.84; length antennal segments I .62, II 2.31, III 2.00, IV 2.48; length labial segments I 1.72, II 1.64, III 2.06, IV 1.20.

Measurements paratypes. 1♂, 2♀. Length ♂ 10.1, ♀ 10.8, 10.7; abdominal width ♂ 2.8, ♀ 2.9, 2.9; head length ♂ 1.38, ♀ 1.54, 1.56; width across eyes ♂ 2.08, ♀ 2.12, 2.20; pronotal length ♂ 1.72, ♀ 1.70, 1.76; pronotal width ♂ 2.94, ♀ 2.92, 3.04; scutellar length ♂ 1.50, ♀ 1.52, 1.52; scutellar width ♂ 1.66, ♀ 1.68, 1.72; length antennal segments I ♂ .60, ♀ .65, .65, II ♂ 2.35, ♀ 2.36, 2.42, III ♂ 2.04, ♀ 2.18, 2.11, IV ♂ 2.52, ♀ 2.62, 2.68; length labial segments I ♂ 1.48, ♀ 1.48, 1.68, II ♂ 1.38, ♀ 1.60, 1.58, III ♂ 1.86, ♀ 2.04, 2.00, IV ♂ 1.14, ♀ 1.18, 1.14.

Comments.—This species is easily separated from the other members of the genus by its large size and completely orange costal hemelytral margins. It is somewhat similar in appearance to *Thunbergia marcida,* sp. nov., but lacks subapical femoral spines. There is at least one closely related species in New Guinea with completely dark hemelytra.

The holotype and two paratypes were taken on the flowers of a rainforest vine (G. B. Monteith, pers. comm.). The species is known only from the type locality (Fig. 7a).

Arocatus montanus, *sp. nov.*

Figures 2a; 3; 46d, g, h; 48i, j; 49k, l; 50a-c; 51c; 52a, b; 53k.

Types.—Holotype ♀, "Bunya Mountains, Qld., 22-I-1938, N. Geary, 200 ft." in AM. Paratypes: 1♂, "Wallacia, III-1932"; 1♂, "Mt. Wilson, N.S.W., I-1929, H.J. Carter"; 1♀, "Lamington National Park, 14/20-II-1958, I.C. Yeo" in AM and UQ.

Description.—Color: Orange. The following dark brown to black: head above; subquadrate postcallar macula on either side of pronotum; crossbar of scutellar carina; mesosternum; metasternum; abdominal sternum VII medially; antenna; labium; and legs. Most of posterior pronotal lobe and scutellum brown. Coriacious parts of hemelytra purplish brown becoming almost black apically. Eye brown. Ocellus red. Hemelytral membrane

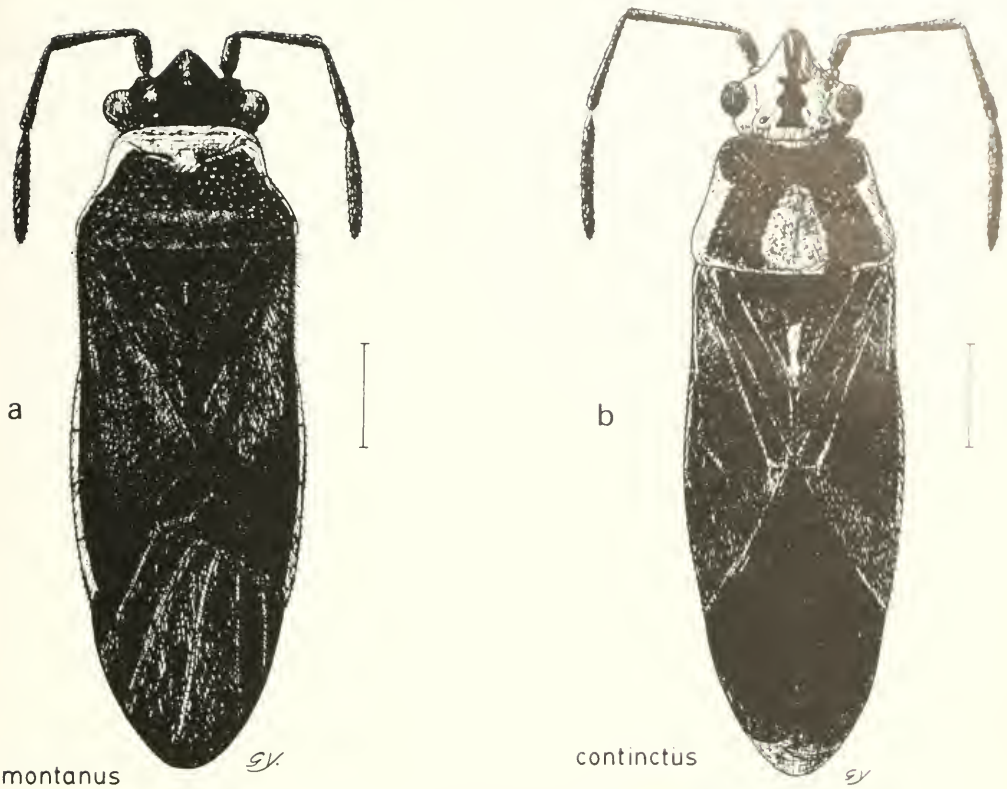


FIG. 2. a. *Arocatus montanus*, sp. nov., dorsal view. b. *A. continctus* Distant, dorsal view. Scale = 1 mm.

subhyaline; dark brown basally becoming paler apically.

Structure: Fairly broad, deep bodied. Head moderately declivent, moderately swollen behind eye; posterior margin of ocellus level with or slightly posterad of posterior margin of eye; buccula moderately prominent, convex, tapering gently posterad. Antennal segment I surpassing anteclypeus by about ⅓ its length. Labial segment I not or just reaching anterior prosternal margin, II reaching about middle of procoxa, III slightly surpassing procoxa, IV reaching mesocoxa. Pronotum very coarsely punctate; scarcely impressed or constricted behind callus; entire anterior lobe and about anterior half of posterior lobe finely granulate giving a dull appearance. Scutellum about 2½ times as long as claval commissure; subacute apically. Hemelytra mesad of radius finely granulate giving a dull appearance. Thoracic pleura deeply, coarsely punctate except acetabular regions. Metapleuron with posterior margin nearly straight, directed dorsoventrally; posterolateral angle not produced. Abdominal sternum II with posterior margin convex laterally; VII of female about ⅙ as long medially as laterally. Abdominal dorsum as in Fig. 46d; mediotergites not elongate or narrowed; VII of both sexes with paratergites apparently fused with mediotergite. Pygophore as in Figs. 46g, h; convex posteriorly; median projection scarcely produced, narrow, without tablike apical process. Clasper as in Figs. 50a-c; caudolateral lobe well de-

veloped; blade flattened, broad basally, gradually narrowed to apex; shank shallowly excavated. Aedeagus somewhat similar to *A. rusticus* (Fig. 49e); phallotheca and phallothecal process as in Figs. 48i, j; conjunctiva elongate, tubular, without lobes; ejaculatory reservoir as in Figs. 49k, l; vesica basally short, thick; ring sclerite heavily pigmented and sclerotized, incomplete, elongate, narrow, extremely convex basally, nearly forming a tube around vesica; vesica distally short, thick, scarcely produced laterally at base, distally forming cup with pigmented outer margins; gonoporal process coiled, moderately elongate (about 3½ coils), visibly covered with membrane for about ⅓ its length, sperm duct narrowing gradually to apex; secondary gonopore not flared or produced, oblique. Ovipositor as in Figs. 52a, b, 53k; first valvula reaching apex of connecting membrane, unmodified; connecting membrane of first valve broadly cleft apically, without sclerites; second valvula narrow, subacute apically; connecting membrane of second valve with median sclerite, not cleft. Spermatheca as in Fig. 51c; sperm pump much nearer apex than base.

Measurements: Holotype ♀. Length 6.9; abdominal width 2.2; head length .66; width across eyes 1.60; pronotal length 1.34; pronotal width 2.24; scutellar length 1.18; scutellar width 1.20; length antennal segments I .36, II .91, III .88, IV 1.16; length labial segments I .66, II .64, III .36, IV .50.

Measurements paratypes. 2♂, 1♀. Length ♂ 6.3, 6.7, ♀ 6.8; abdominal width ♂ 1.9, 2.2, ♀ 2.3; head length ♂ .56, .64, ♀ .64; width across eyes ♂ 1.50, 1.60, ♀ 1.56; pronotal length ♂ 1.16, 1.40, ♀ 1.36; pronotal width ♂ 2.04, 2.24, ♀ 2.26; scutellar length ♂ 1.08, 1.16, ♀ 1.20; scutellar width ♂ 1.08, 1.26, ♀ 1.28; length antennal segments I ♂ .34, .37, ♀ .36, II ♂ .92, .97, ♀ .95, III ♂ .93, ♀ .90, IV ♂ 1.20, ♀ 1.16; length labial segments I ♂ .60, .66, ♀ .68, II ♂ .58, .62, ♀ .60, III ♂ .34, .34, ♀ .30, IV ♂ .48, .56, ♀ .56.

Comments.—The extremely short labium separates *Arocatus montanus* from all other Australian members of the genus. The dorsal color pattern is reminiscent of that of *A. melanocephalus* from the Palearctic region. A very closely related undescribed species from New Guinea differs from *A. montanus* in that it is larger, the hemelytral membranes are relatively longer and more acute apically, the punctations are sparser and deeper, the antennae are longer and comparatively thinner, the meso- and metapleura are infuscated, the abdominal venter is completely orange, and labial segments I and II are orange.

From the few specimens examined *A. montanus* seems to be restricted to upland rainforest areas in New South Wales and eastern Queensland (Fig. 3). Nothing is known of its biology.

Arocatus continctus *Distant 1906*

Figures 2b; 3; 46e; 48g, h, m, n; 49a, b, j; 50d-f; 51b; 52e, f; 53l.

Arocatus continctus Distant, 1906:410; Slater, 1964*a*:20, 1964*b*:57; Hamid and Meher, 1973*a*:36; Slater, 1978: 856.

Graptostethus parvus Distant, 1918:422; Slater, 1964*a*:55. syn. nov.

Types.—Lectotype ♀ of *A. continctus,* "Eppawela, N.C.P. 9-05, 1888, Distant Coll., 1911-383" in BMNH. Paralectotypes of *A. continctus,* 3♂, same data as lectotype, in BMNH. Type ♂ of *G. parvus,* "Townsville, Qld., July-03, F.P. Dodd." in BMNH.

Redescription.—Color: Orange. The

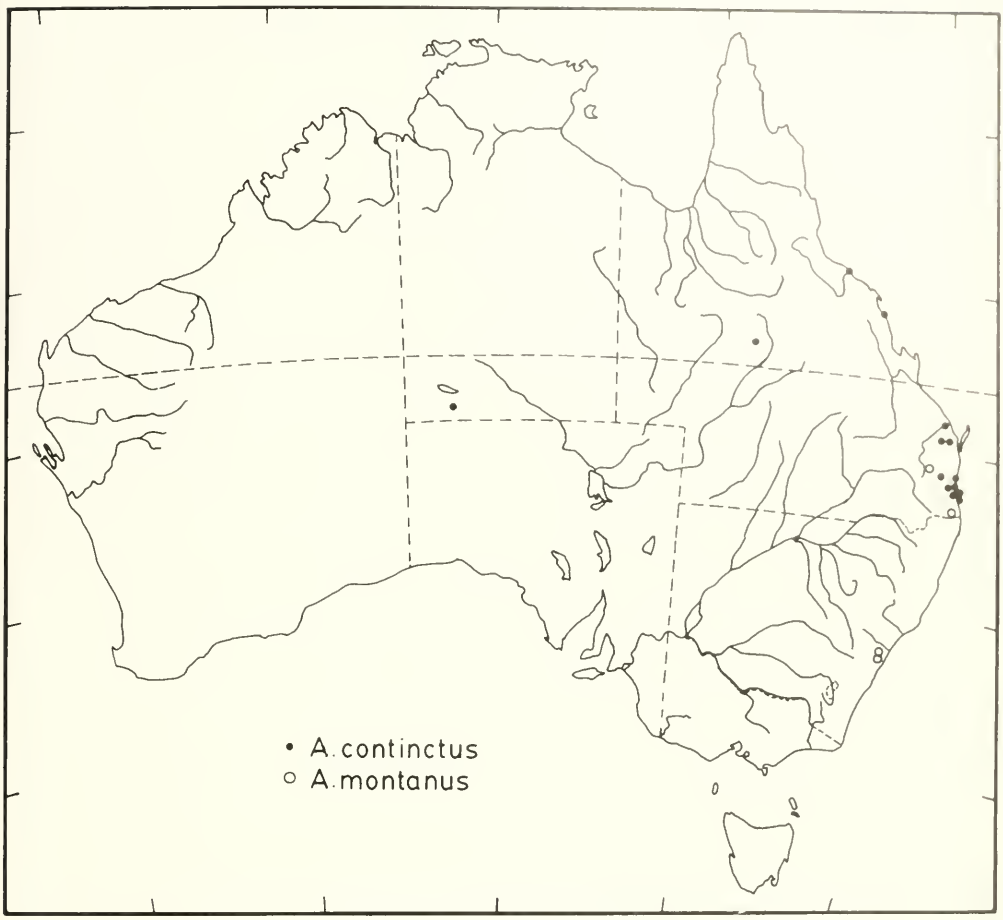


FIG. 3. Distribution of *Arocatus continctus* Distant and *A. montanus*, sp. nov. in Australia.

following dark brown to black: median longitudinal dorsal vitta of head; anterior pronotal lobe; broad longitudinal vitta on either side of posterior pronotal lobe, connecting with anterior lobe; scutellum except narrow median longitudinal vitta and apex; clavus except margin of claval suture; diffuse triangular macula along costal corial margin not reaching either base or apex, broadest opposite claval apex; prosternum except anterior margin; meso- and metasterna; propleuron except anterior margin, posterior half of lateral margin and acetabula; mesopleuron except lateral margin and acetabula; metapleuron except lateral and posterior margins, acetabula, and ostiolar peritreme; abdominal sternum VII medially; genital segments medially in females, completely in males; antennal segments I to III; labium; and legs except trochanters and distal margins of coxae. The following pale yellow: acetabulae; ostiolar peritreme; trochanters; and distal margins of coxae. Antennal segment IV dark brown basally, light brown apically. Eye brown. Ocellus red. Hemelytral membrane subhyaline, brown basally becoming almost clear apically.

Structure: Fairly broad, deep bodied. Head slightly declivent, strongly swollen behind eye; posterior margin of

ocellus level with or posterad of posterior margin of eye; buccula moderately produced, slightly convex, tapering gently posterad. Antennal segment I surpassing anteclypeus by about ¼ its length. Labial segment I not or just reaching anterior prosternal margin, II slightly surpassing procoxa, III slightly surpassing mesocoxa, IV reaching abdominal sternum III. Pronotum moderately coarsely punctate; postcallar impression interrupted on either side by a short submedial ridge; anterior lobe and about anterior half of posterior lobe finely granulate giving a dull appearance. Scutellum about twice as long as claval commissure; subacute apically; entire base finely granulate giving a dull appearance. Thoracic pleura coarsely, shallowly punctate anteriorly, impunctate posteriorly; posterolateral metapleural angle slightly produced; posterior metapleural margin directed slightly anteroventrally. Abdominal sternum II about half covered by metapleuron, posterior margin nearly straight; VI of female about ⅙ as long medially as laterally. Abdominal dorsum as in Fig. 46e; mediotergites IV and V elongate, narrowed laterally, most strongly in female. Pygophore as in Figs. 48m, n; convex posteriorly; median projection short, narrow, lacking tablike apical process; tergum IX distinct, not depressed medially. Clasper as in Figs. 50d-f; caudolateral lobe moderately developed; blade flattened, very broad basally; sharply curved and narrowed apically; shank moderately excavated interiorly. Aedeagus as in Fig. 49j; phallotheca and phallothecal process as in Figs. 48g, h; conjunctiva elongate, without lobes; ejaculatory reservoir as in Figs. 49a, b; vesica basally tubular, about as thick as conjunctiva, twisted, without lobes; ring sclerite complete or nearly so, broadest basally; vesica apically coiled, flattened, greatly produced laterally especially at ring sclerite, grooved to receive retracted gonoporal process; gonoporal process very long, twisted, corkscrew-like subapically; secondary gonopore oblique, without apical process. Ovipositor as in Figs. 52e, f, 53l; first valvula reaching apex of connecting membrane, produced basolaterad subapically; connecting membrane of first valve broadly notched medially, lacking sclerites; second valvula produced ventrad subapically, scarcely thickened apically; connecting membrane of second valve reaching almost to apex of valvula, slightly produced and pigmented medially. Spermatheca as in Fig. 51b: tightly coiled immediately basad of apical bulb; cup shaped flange usually (not always) covering coiled section; sperm pump immediately basad of coiled section.

Measurements: Length ♂ 6.6 (6.1-7.2), ♀ 7.4 (6.7-8.4); abdominal width ♂ 2.0 (1.9-2.1), ♀ 2.3 (2.0-2.5); head length ♂ .90 (.86-.93), ♀ 1.07 (.99-1.18); width across eyes ♂ 1.45 (1.32-1.55), ♀ 1.59 (1.45-1.73); pronotal length ♂ 1.13 (1.05-1.18), ♀ 1.28 (1.13-1.45); pronotal width ♂ 1.97 (1.81-2.20), ♀ 2.25 (2.00-2.51); scutellar length ♂ 1.08 (1.00-1.21), ♀ 1.19 (1.05-1.35); scutellar width ♂ 1.11 (1.00-1.30), ♀ 1.29 (1.13-1.50); length antennal segments I ♂ .35 (.30-.38), ♀ .38 (.35-.42), II ♂ 1.09 (1.03-1.25), ♀ 1.15 (1.05-1.29), III ♂ .94 (.86-1.11), ♀ 1.06 (.86-1.13), IV ♂ 1.26 (1.16-1.38), ♀ 1.35 (1.23-1.44); length labial segments I ♂ .89 (.83-.98), ♀ 1.03 (.93-1.13), II ♂ .92 (.85-1.04), ♀ 1.07 (.93-1.18), III ♂ .90 (.83-1.01), ♀ 1.05 (.94-1.18), IV ♂ .60 (.58-.63), ♀ .65 (.60-.71).

Comments.—Arocatus continctus is easily separated from other Australian members of the genus by the pronotal

markings and the orange median scutellar vitta. The dark hemelytral markings are variable in extent, often covering the entire clavus and corium. The abdominal venter is sometimes nearly completely infuscated medially, approaching the appearance of *Graptostethus* species.

Distant (1918) described a light colored specimen as *Graptostethus parvus* and stated that it was allied to *G. cardinalis* (Stål). The two species are somewhat similar in general appearance and somewhat atypical of their respective genera, at least considering only Australian species. They do, however, conform to the basic generic characteristics.

Arocatus continctus has a curious disjunct distribution, occurring in western Africa, India and Australia. In Australia it is apparently almost restricted to the eastern coastal region of Queensland (Fig. 3). It is often found in large numbers within and on the pods of "Wild Cotton" (*Gomphocarpus* spp.). I have also found adults and nymphs on *Nerium oleander*.

I believe that this species is oriental and was introduced fairly recently to Africa and Australia. The male and female genitalia differ considerably from other members of the genus I have examined while a species from the Ryukyu Islands tentatively identified as *A. fasciatus* Jakovlev has genitalia very similar to those of *A. continctus*.

Arocatus aenescens *Stål 1874*

Figures 4; 7a; 46f; 47c, d; 48e, f; 49m, n; 50p-r; 51e; 53c, d, i.

Arocatus aenescens Stål, 1874:115-116; Slater, 1964*a*:19.

Scopiastes bergrothi Kirkaldy, 1903:16.

Type.—Type ♀, "Australia" in Stockholm.

Redescription.—Color: Brown. The following orange: head except longitudinal median vitta dorsally; scutellar apex; thoracic pleura except acetabulae; posterior metapleural margin and ostiolar peritreme; abdominal sterna; and abdominal terga except VII posteriorly. The following pale yellow: anterior prosternal and propleural margins; posterior margins of abdominal sterna; acetabulae; posterior metapleural margin; ostiolar peritreme; apices of coxae; trochanters; and extreme bases of femora. Antenna and labium dark brown to black; antennal segment IV lighter apically. Eye brown. Ocellus red. Hemelytral membrane subhyaline, dark brown basally, lighter apically.

FIG. 4. *Arocatus aenescens* Stål, dorsal view. Scale = 1 mm.

Structure: Narrow, elongate. Head slightly declivent, moderately swollen behind eye; posterior margin of ocellus anterad of posterior margin of eye;

buccula moderately produced, slightly convex, tapering gently posterad. Antennal segment I surpassing anteclypeus by about 1/3 its length. Labial segment I not reaching anterior prosternal margin, II reaching middle of procoxa, III reaching mesocoxa, IV reaching about middle of metacoxa. Pronotum coarsely punctate, finely granulate dull area restricted to anterior angles. Scutellum about 1 1/4 times as long as claval commissure; acute apically; finely granulate dull area restricted to basal angles. Pro- and mesopleura except acetabulae coarsely punctate. Metapleuron except acetabula and narrow posterior margin coarsely punctate; posterior margin very slightly concave, directed dorsoventrally; posterolateral angle not produced. Abdominal sternum II convex laterally; VI of female about 2/3 as long medially as laterally. Abdominal dorsum as in Fig. 46f; mediotergites IV and V somewhat elongate, slightly narrowed at common margin. Pygophore as in Figs. 47c, d; nearly truncate posteriorly; short tablike process at apex of median projection; tergum IX moderately broad, impressed medially. Clasper as in Figs. 50p-r; caudolateral lobe scarcely indicated; blade narrow, rounded in cross section; shank excavated, with moderately projecting overhang. Aedeagus similar to *A. rusticus* (Fig. 49e); phallotheca and phallothecal process as in Figs. 48e, f; ejaculatory reservoir as in Figs. 49m, n. Ovipositor as in Figs. 53c, d, i; resembling *A. rusticus*; connecting membrane of first valve cleft medially, cleft surrounded by sclerotized area; apex of second valvula bluntly produced dorsoapically. Spermatheca as in Fig. 51e; sperm pump near base.

Measurements: Length ♂ 6.0 (5.6-6.4), ♀ 6.6 (6.2-7.1); abdominal width ♂ 1.8 (1.7-1.9), ♀ 2.0 (1.8-2.2); head length ♂ .86 (.72-1.00), ♀ .96 (.90-1.08); width across eyes ♂ 1.44 (1.36-1.48), ♀ 1.56 (1.50-1.62); pronotal length ♂ 1.11 (1.00-1.16), ♀ 1.19 (1.08-1.30); pronotal width ♂ 1.74 (1.64-1.84), ♀ 1.97 (1.86-2.08); scutellar length ♂ .82 (.76-.90), ♀ .92 (.80-.96); scutellar width ♂ .90 (.84-1.00), ♀ 1.04 (.92-1.08); length antennal segments I ♂ .39 (.36-.41), ♀ .40 (.36-.43), II ♂ .95 (.91-.98), ♀ 1.00 (.96-1.05), III ♂ .86 (.80-.91), ♀ .92 (.88-.97), IV ♂ 1.06 (.96-1.20), ♀ 1.14 (1.00-1.23); length labial segments I ♂ .74 (.70-.76), ♀ .82 (.76-.86), II ♂ .75 (.72-.86), ♀ .82 (.76-.88), III ♂ .66 (.62-.74), ♀ .76 (.72-.86), IV ♂ .69 (.64-.72), ♀ .78 (.74-.82).

Comments.—Arocatus aenescens is the smallest Australian member of the genus and the only one with unicolored pronotum and hemelytra. In the field it could be mistaken for dark specimens of *A. continctus* from which it is easily separated by the orange thoracic pleura. The extent of the dark dorsal vitta on the head is variable, sometimes covering the entire vertex and occasionally confined to the apex of the anteclypeus. There is often an indistinct longitudinal vitta on either side of the abdominal venter. A single male from northern Queensland has dark thoracic pleura.

This species is closely related to *A. rusticus* (Stål) and *A. chiasmus,* sp. nov. It differs from those two species in the placement of the median sclerite of the membrane connecting the first valvulae of the ovipositor and in the only slightly elongate and scarcely narrowed fourth and fifth mediotergites of the abdominal dorsum, approaching *A. montanus,* sp. nov., in the latter characteristic. *Arocatus aenescens* occurs in the eastern coastal part of Australia from New South Wales to the Torres Strait (Fig. 7a). The species appears to be

associated primarily with lowland rainforest. It has been collected in large numbers under bark in New South Wales. In Queensland I have found it commonly on *Parsonsia straminia* and occasionally on *Gomphocarpus* spp.

Arocatus rusticus *Stål 1867*

Figures 5b; 6; 46a; 47a, b; 48a, b; 49e-g; 50g-i; 51a; 53a, b, g.

Tetralaceus (sic) *rusticus* Stål, 1867:163.
Astacops ? caligatus Walker, 1872:36-37.
Lygaeus subjectus Walker, 1872:62.
Lygaeus singularis Walker, 1872:63; Lethierry and Severin, 1894:157; Distant, 1901*a*:541; Slater, 1964*a*:117. syn. nov.
Lygaeus ruficollis Walker, 1872:64.
Arocatus rusticus Stål, 1874:115; Slater, 1964*a*:28-29; Slater, 1978:857.
Arocatus ruficollis B.-White, 1878:32; Tillyard, 1926:11, 146.

Types.—Lectotype ♂ of *rusticus*, "Austral. boreal. Thorey." in Stockholm. Paralectotype ♀ of *rusticus*, same data as lectotype, in Stockholm. Type of *L. singularis* lost *fide* Distant, 1914*a*.

Redescription.—Color: Reddish orange. The following dark brown to black: head dorsally including antenniferous tubercle and swollen area behind eye; posterior pronotal lobe except extreme posterior margin; scutellum except apex; triangular macula along costal margin of corium from near base to about ⅙ distance from apex, subparallel to claval suture and apical margin, widest opposite apex of clavus; meso- and metasterna except raised posterior margins; rounded cen-

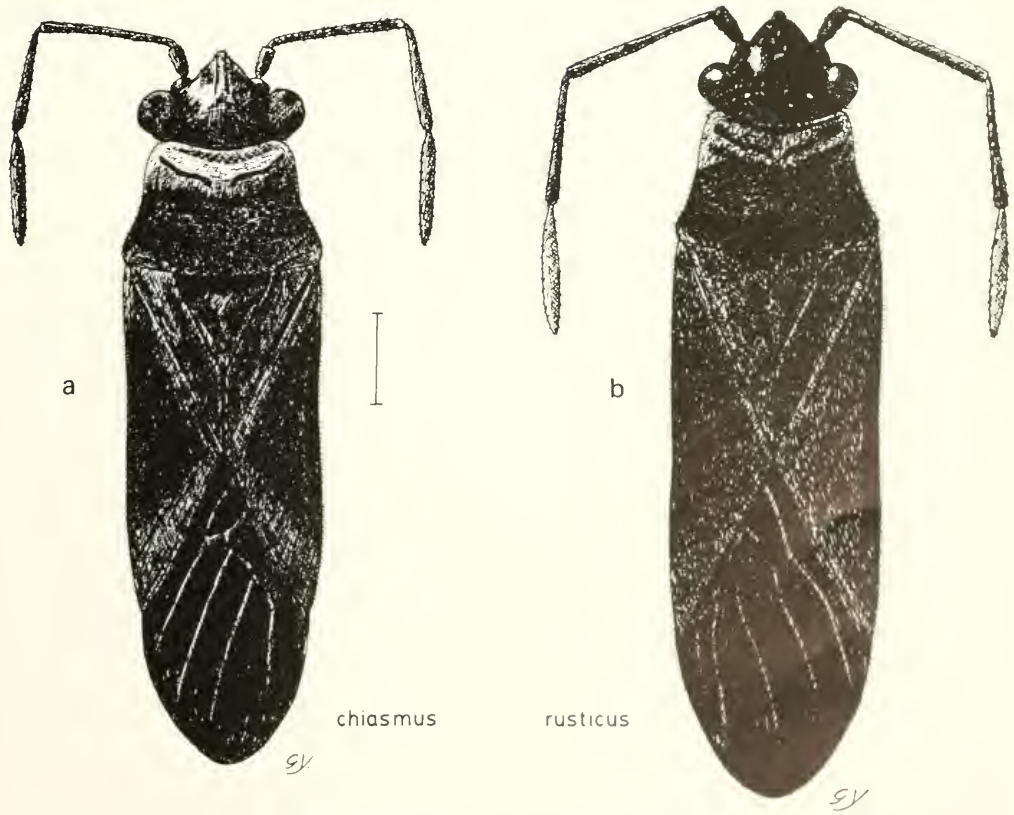


FIG. 5. a. *Arocatus chiasmus*, sp. nov., dorsal view. b. *Arocatus rusticus* (Stål), dorsal view. Scale = 1 mm

tral macula near lateral margin of abdominal sternum VI; similar macula on sternum VII, sometimes expanded to cover entire sternum except lateral margin; genital segments; antenna; labium; and legs. The following pale yellow: anterior prosternal and propleural margins; posterior margins of all thoracic sterna; posterior margins and acetabulae of all thoracic pleura; buccula; and sometimes posterior pronotal margin. Eye brown. Ocellus red. Hemelytral membrane subhyaline; basal angle whitish, otherwise dark brown basally becoming paler apically.

Structure: Narrow, elongate. Head scarcely declivent, slightly swollen behind eye; posterior margin of ocellus anterior to posterior margin of eye; buccula moderately produced, slightly convex, tapering gently posteriorly. Antennal segment I surpassing anteclypeus by about 1/4 its length. Labial segment I surpassing anterior prosternal margin by about 1/3 its length, II reaching middle of mesosternum, III reaching anterior margin of abdominal sternum III, IV reaching abdominal sternum IV. Pronotum moderately coarsely punctate; anterior lobe including callus finely granulate giving a dull appearance. Scutellum about 1 1/4 times as long as claval commissure; acute apically; entire base finely granulate giving a dull appearance. Propleuron coarsely punctate anteriorly and posteriorly, indistinctly punctate centrally. Meso- and metapleura indistinctly punctate anteriorly, coarsely punctate posteriorly except impunctate posterior margins; posterior metapleural margin slightly concave, directed dorsoventrally; posterior metapleural angle not produced. Abdominal sternum II with posterior margin convex laterally; VI of female about 2/3 as long medially as laterally. Abdominal dorsum as in Fig. 46a; mediotergites IV and V strongly narrowed to their common margin, most strongly in female. Pygophore as in Figs. 47a, b; concave posteriorly; median projection with tablike apical process; tergum IX narrow, impressed medially. Clasper as in Figs. 50g-i; caudolateral lobe slightly indicated; blade evenly curved to apex, rounded in cross section; shank excavated interiorly, overhang strongly produced, somewhat tentlike. Aedeagus as in Fig. 49e; phallotheca as in Figs. 48a, b; conjunctiva elongate, tubular, with notched, pigmented subapical lobe dorsally; ejaculatory reservoir as in Figs. 49f, g; vesica basally moderately long, twisted, slightly flattened and produced laterally; ring sclerite incomplete, moderately elongate, scarcely convex; vesica distally tightly coiled, expanded laterally for entire length, when retracted forming cuplike receptacle for retracted gonoporal process; gonoporal process short, slightly constricted subapically, visibly covered by membrane to apex; secondary gonopore flared, without apical process. Ovipositor as in Figs. 53a, b, g; first valvula not reaching apex of connecting membrane, ventral margin notched subapically; connecting membrane of first valve with median and sublateral sclerites, the latter reaching apex of membrane; second valvula slightly swollen subapically, a very acute curved projection at apex; connecting membrane of second valve deeply cleft medially. Spermatheca as in Fig. 51a; sperm pump much closer to base than to apex.

Measurements: Length ♂ 8.3 (7.7-8.9), ♀ 9.0 (8.1-9.8); abdominal width ♂ 2.2 (2.0-2.4), ♀ 2.5 (2.2-2.7); head length ♂ 1.17 (1.08-1.24), ♀ 1.27 (1.14-1.44); width across eyes ♂ 1.85 (1.72-1.96), ♀ 1.97 (1.80-2.16); pronotal length ♂ 1.38 (1.28-1.52), ♀ 1.47 (1.26-1.68); pronotal width ♂ 2.31

(2.12-2.50), ♀ 2.48 (2.20-2.72); scutellar length ♂ 1.13 (.92-1.26), ♀ 1.22 (1.12-1.32); scutellar width ♂ 1.28 (1.14-1.36), ♀ 1.41 (1.24-1.54); length antennal segments I ♂ .50 (.48-.54), ♀ .53 (.48-.59), II ♂ 1.71 (1.66-1.84), ♀ 1.85 (1.63-2.03), III ♂ 1.42 (1.33-1.54), ♀ 1.53 (1.36-1.75), IV ♂ 1.43 (1.29-1.55), ♀ 1.50 (1.33-1.59); length labial segments I ♂ 1.33 (1.28-1.40), ♀ 1.50 (1.33-1.59), II ♂ 1.35 (1.30-1.40), ♀ 1.57 (1.36-1.76), III ♂ 1.61 (1.50-1.76), ♀ 1.83 (1.52-2.08), IV ♂ .97 (.92-1.00), ♀ 1.05 (.92-1.16).

Comments.—*Arocatus rusticus* is very similar to *A. chiasmus,* sp. nov., in general appearance but lacks dark markings on the thoracic pleura and has a longer labium. The extent of the triangular corial macula is quite variable, sometimes reduced to little more than a thin line along the corial margin and sometimes covering almost the whole corium. Dark specimens might be confused with *A. montanus,* sp. nov., but are easily separated from that species by the black maculae on either side of the abdominal venter near its apex.

In Australia *A. rusticus* occurs only in the east, its range extending from Tasmania in the south as far north as the Tropic of Capricorn (Fig. 6). The species also occurs on Lord Howe and Norfolk islands and in New Zealand. It is apparently tolerant of more diverse climatic conditions than are most members of the genus and has a wider range of food plants. Adults and nymphs have been collected on *Parsonsia straminia, Araujia hortorum, Nerium oleander* and *Gomphocarpus* sp. Adults have also been taken on *Asclepias currasavica.*

A parasitic fly, *Alophora aureiventris* Curran (Tachinidae), emerged from a female collected in Brisbane and kept alive in the laboratory. The fly larva emerged at the base of the ovipositor, killing the host. This tachinid has been recorded from the pyrrhocorid *Dysdercus sidae* Montrouzier from several localities in Queensland (B. Cantrell, pers. comm.).

Arocatus chiasmus, *sp. nov.*

Figures 5a; 6; 46b; 47e, f; 48c, d; 49c, d; 50m-o; 51d; 53e, f, h.

Types.—Holotype ♂, "Richmond, Queensland, VIII-1965, A. Fenwick" in QM. Paratypes: 2♂, 1♀, same data as holotype, in UQ. Also: Western Australia—1♀, 8 mi S of Lansdowne Homestead, 21-28.vi.1964, R. Plumb; 1♀, 8 mi S of Lansdowne Homestead, 1.ix.1964, R. Plumb; 1♂, 8 mi S of Lansdowne Homestead, 4.ix.1964, R. Plumb; 1♀, 4 km ESE of Millstream, 21.36S, 117.07E, 31.x.1970, M. Upton and J. Feehan (ANIC); 1♀, Fortescue River Hammersley Range, W. D. Dodd (SAM); 1♀, 39481 mileage N of White Mountain S of Rosewood Station, 29.v.1970, Lemley Expedition (WAM); Northern Territory—1♂, Amadeus Basin, 3.vii.1962, P. Ranford, swept from foliage; 1♀, Burnside, Brock's Creek, 18.iv.1929, T. G. Campbell; 1♀, 1 km N of Cahill's Crossing, East Alligator River, 12.25S, 132.58E, 8-9.xi.1972, J. C. Cardale; 1♀, 7 km NW by N of Cahill's Crossing, 12.23S, 132.56E, 12.xi.1972, Upton and Feehan; 1♂, 1 km S of Cahill's Crossing, 12.26S, 132.58E, 3.xi.1972, Upton and Barrett; 1♀, 4 mi W of Coolibah Homestead, 15.34S, 130.54E, 6.vii.1968, M. Mendum; 1♀, Koongarra, 12.52S, 132.50E, 16.xi.1971, V. E. Ingle; 1♂, 12 km NNW of Mt. Cahill, 12.46S, 132.39E, 25.x.1972, M. Upton (ANIC); 1♂, 1♀, Port Keats, ix-x.1973, R. Easton (NMV); 1♂, Darwin, xii.1963, W.

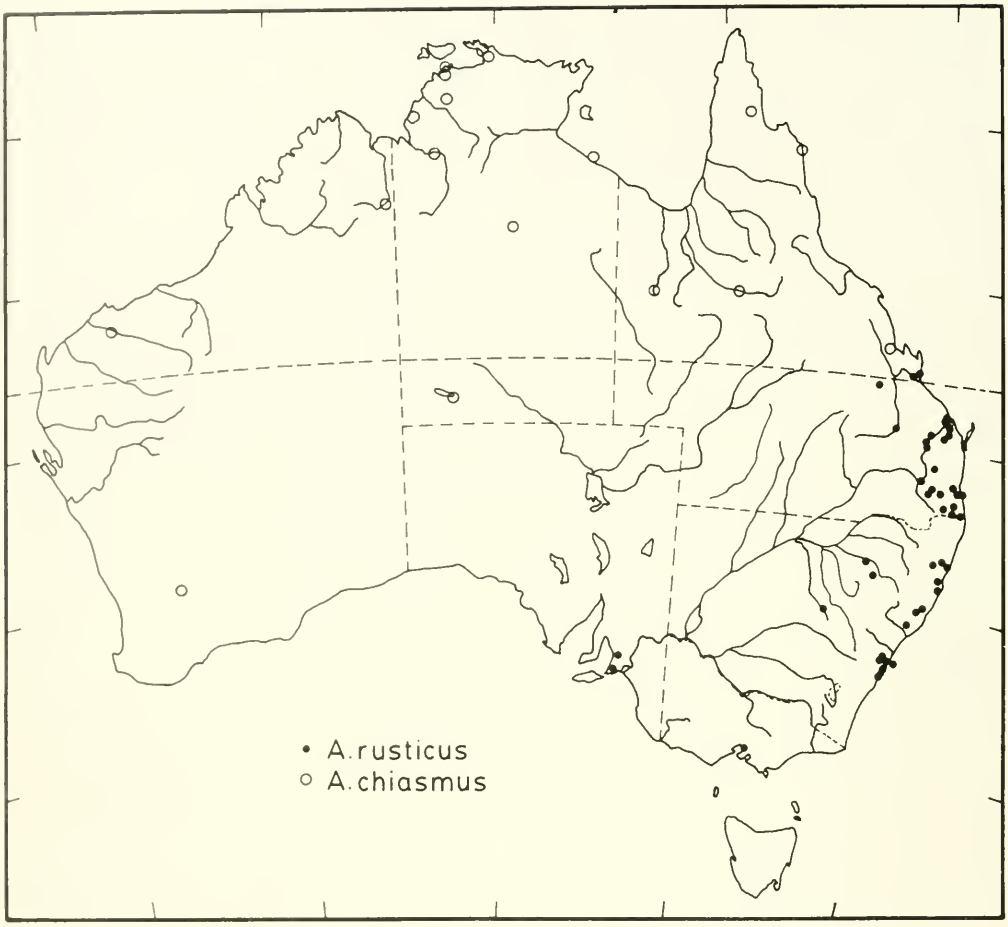


FIG. 6. Distribution of *Arocatus rusticus* (Stål) and *A. chiasmus*, sp. nov. in Australia.

P. Walsh (SAM); 1♀, Swim Creek, 13.x.1971, Wein and Allwood (PIBNTH); 1♀, 4.8 km S of Renner Springs, 8.iii.1966, N. McFarland, at UV light; 1♂, 10 mi NW of Yuerduni Creek bed, 20.ii.1968, at light (SAM); 1♀, Horn Islet, Sir Edward Pellew Group, 22-28.ii. 1968, B. Cantrell; 1♀, Horn Islet, Sir Edward Pellew Group, 18.viii. 1967, M. C. McKee (DPI); Queensland—1♀, Clermont, 20.ix.1928, Dr. K. K. Spence (AM); 1♂, Gap Creek, 6 mi N of Bloomfield River, 13-14.x.1965, G. Monteith; 1♂, Lankelly Creek, McIlwraith Range, near Coen, Cape York Peninsula, 28-31.x.1969, B. Cantrell; 1♂, 2♀, Mica Creek, 8 mi S of Mt. Isa, 20.iii.1973, E. M. Exley, on *Tristania grandiflora* (UQ).

Description.—Color: Orangey red. The following dark brown to black: apex of anteclypeus; posterior pronotal lobe except broad posterior margin; scutellum except apex; clavus apically along scutellar margin; triangular macula along central half of costal corial margin, widest opposite apex of clavus; produced posterior part of propleuron; mesopleuron except acetabula; metapleuron except lateral, posterior, and acetabular margins and ostiolar per-

itreme; transversely ovate macula laterally on abdominal sterna VI and VII; genital segments; and antennal segments I, II, III, and base of IV. The following pale yellow: anterior prosternal margin; posterior margins of thoracic sterna; anterior, posterior, and acetabular propleural margins; acetabulae of meso- and metapleura; and ostiolar peritreme. Eye brown. Ocellus red. Posterior margin of pronotum, apex of scutellum, antennal segment IV apically, labium, and legs brown. Hemelytral membrane subhyaline, basal angle whitish, otherwise dark brown basally becoming paler apically.

Structure: Narrow, elongate. Head slightly declivent, slightly swollen behind eye; posterior margin of ocellus level with or anterior to posterior margin of eye; buccula moderately produced, slightly convex, tapering gradually posterad. Antennal segment I surpassing anteclypeus by about 1/4 its length. Labial segment I surpassing anterior prosternal margin by about 1/6 its length, II surpassing anterior 1/4 of mesosternum, III reaching metacoxa, IV surpassing anterior 1/2 of abdominal sternum III. Pronotum moderately coarsely punctate; anterior lobe including callus finely granulate appearing dull. Scutellum about 1 1/4 times as long as claval commissure; acute apically; narrow band at base finely granulate appearing dull. Propleuron coarsely punctate anteriorly and posteriorly, moderately coarsely punctate centrally, acetabula impunctate. Mesopleuron moderately heavily punctate except impunctate lateral margin and acetabula. Metapleuron moderately punctate except impunctate lateral and posterior margins and acetabula; posterior margin slightly concave, directed dorsoventrally; posterolateral angle not produced. Abdominal sternum II convex laterally, VI of female about 2/3 as long medially as laterally. Abdominal dorsum as in Fig. 46b; mediotergites IV and V elongate, narrowed to their common margin. Pygophore as in Figs. 47e, f; posterior margin moderately concave; median projection with tablike apical process; tergum IX wide, expanded laterally at posterior margin, impressed medially. Clasper as in Figs. 50m-o; very similar to *A. rusticus* except margin of shank's excavation "rolled." Aedeagus similar to *A. rusticus* (Fig. 49e); gonoporal process longer, thicker, more strongly constricted subapically; secondary gonopore more strongly flared; phallotheca and phallothecal process as in Figs. 48c, d; ejaculatory reservoir as in Figs. 49c, d. Ovipositor as in Figs. 53e, f, h; similar to *A. rusticus* except apical projection of second valvula less curved. Spermatheca as in Fig. 51b; tube thick for genus; sperm pump slightly further from base than from apex.

Measurements: Holotype ♂. Length 7.6; abdominal width 2.1; head length 1.02; width across eyes 1.88; pronotal length 1.40; pronotal width 2.24; scutellar length 1.06; scutellar width 1.08; length antennal segments I .43, II 1.44, III 1.20, IV 1.36; length labial segments I 1.02, II 1.00, III 1.20, IV .76.

Measurements of paratypes. Length ♂ 7.7 (6.9-8.0), ♀ 8.3 (7.5-9.2); abdominal width ♂ 2.1 (1.8-2.2), ♀ 2.4 (2.1-2.8); head length ♂ 1.01 (.92-1.10), ♀ 1.02 (.84-1.26); width across eyes ♂ 1.84 (1.66-1.94), ♀ 1.97 (1.82-2.18); pronotal length ♂ 1.35 (1.16-1.46), ♀ 1.45 (1.26-1.66); pronotal width ♂ 2.15 (1.84-2.32), ♀ 2.42 (2.14-2.68); scutellar length ♂ .99 (.84-1.10), ♀ 1.15 (1.00-1.30); scutellar width ♂ 1.04 (.80-1.16), ♀ 1.20 (1.04-1.36); length antennal segments I ♂ .42 (.40-.44), ♀ .44 (.41-.47), II ♂ 1.44 (1.25-1.53), ♀ 1.53 (1.40-1.64), III ♂ 1.17

(1.06-1.24), ♀ 1.25 (1.14-1.36), IV ♂ 1.31 (1.27-1.36), ♀ 1.38 (1.27-1.52); length labial segments I ♂ 1.02 (.90-1.10), ♀ 1.15 (1.06-1.24), II ♂ 1.00 (.86-1.10), ♀ 1.13 (1.04-1.20), III ♂ 1.19 (1.10-1.24), ♀ 1.30 (1.12-1.40), IV ♂ .77 (.72-.82), ♀ .80 (.72-.84).

Comments.—Arocatus chiasmus is very similar to *A. rusticus* with which it forms a north-south species pair. It may be separated from *rusticus* by the dark thoracic pleura and shorter labium. The reddish orange head is a very distinctive character when present but is frequently as dark as light examples of *rusticus*.

This species is apparently restricted to northern Australia, occurring as far south as the Tropic of Capricorn (Fig. 6). It appears to be associated with drier areas than the other Australian members of the genus.

Astacops Boisduval

Astacops Boisduval, 1835:637; Scudder, 1963:319-324; Slater, 1964*a*:33; Blöte, 1972:410-411.

Montaltus Distant, 1888:483.

Type-species *Astacops australis* Boisduval, 1835 (fixed by Distant, 1904).

At one time *Astacops* contained all Lygaeinae with distinctly stylate eyes. The group was revised by Scudder (1963) who provided keys and diagnoses for the genera and species within the complex. He recognized four genera, two of which, *Astacops* and *Scopias-*

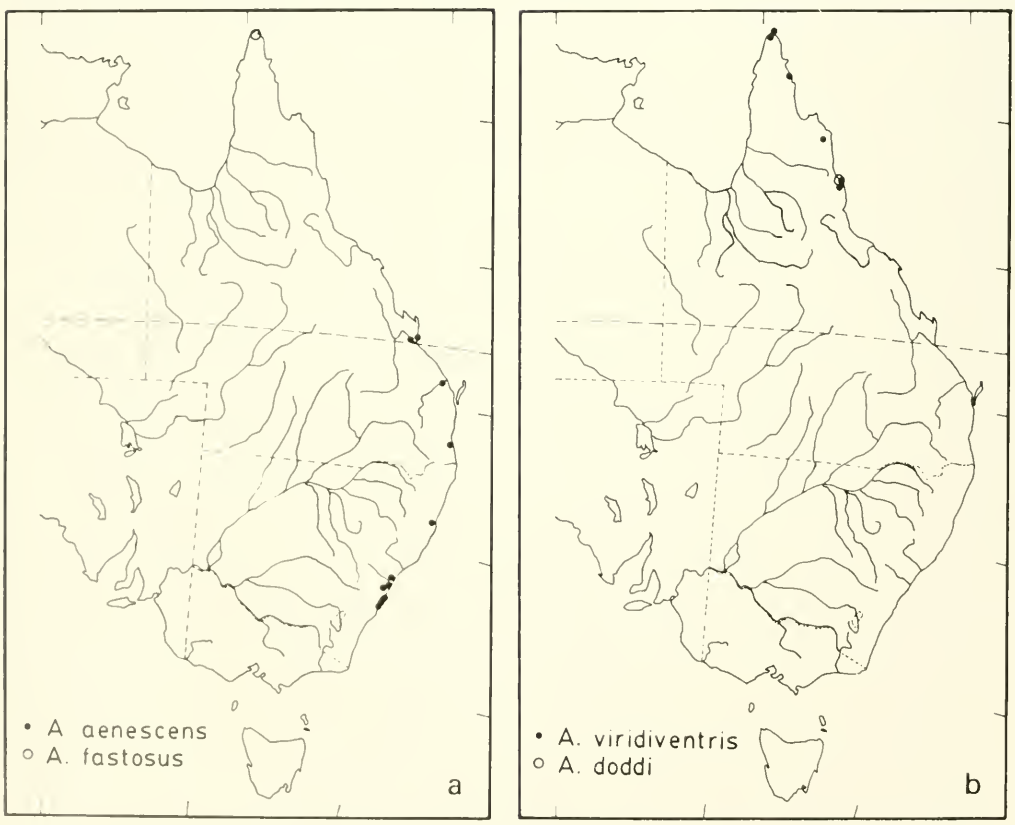


FIG. 7 a. Distribution of *Arocatus aenescens* Stål and *A. fastosus*, sp. nov. in Australia. b. Distribution of *Astacops viridiventris* Stål and *A. doddi* Scudder in Australia.

tes, occur in Australia. In this paper I am erecting the genus *Woodwardiastes,* and elevating the subgenus *Scopiastella* to generic level. This brings the total of Australian genera with stylate eyes to four. The generic divisions within the *Astacops* complex are difficult to define concisely. Genitalic characters are by far the best to use in doubtful cases.

As Scudder (1963) has given a generic diagnosis for *Astacops* I do not feel it necessary to provide one here. However his specific descriptions, while generally adequate for ssparating species, are minimal—especially as regards structure. Further, I have found that I disagree with some of his color designations for the Australian species. I therefore give rather detailed species descriptions.

As presently constituted *Astacops* contains about 50 species with the greatest number occurring in New Guinea. Scudder (1963) split the genus into three groups based on the structure of the aedeagus and spermatheca. He placed the two Australian species in the *Astacops dorycus* group, characterized by an S-shaped portion of the spermatheca near the apical bulb and a lateral flange near the aedeagal ring sclerite. Both Australian species are restricted to northern Queensland in Australia. One is apparently endemic and the other also occurs in New Guinea. The two species are very similar structurally and may be separated from other Australian Lygaeinae with stylate eyes by their large size and rather robust bodies.

Key to the Australian Species of Astacops

1. Pronotum black; abdominal venter red, tinged with orange, and without transverse fasciae . . . . . *doddi* Scudder

1′. Pronotum pale yellow or orange; abdominal venter pale yellow, often suffused with green, and usually with transverse fasciae on segments IV to VI . . . . . *viridiventris* Stål

Astacops viridiventris *Stål 1874*

Figures 7b; 8; 54f-j; 55a-i

Astacops viridiventris Stål, 1874:100; Scudder, 1963:370; Slater, 1964*a*: 38.

Astacops subochraceus Distant, 1918:416; Slater, 1964*a*:37.

Types.—Lectotype ♂, "Cape York. Thorey." in Stockholm. Paralectotypes: 1 ♂, 4 ♀, same data as lectotype, in Stockholm.

Redescription.—Pale yellow. The following orangey red: head except venter medially; base of antennal segment I; pronotal humerus; coreaceous part of hemelytron, becoming darker apically; often apical half of fore and mid femora; and sometimes scutellum. The following dark brown to black: apex of anteclypeus; eye; antenna except base of segment I; labium; sometimes scutellum; legs except coxae and apical part of fore and mid femora; sometimes

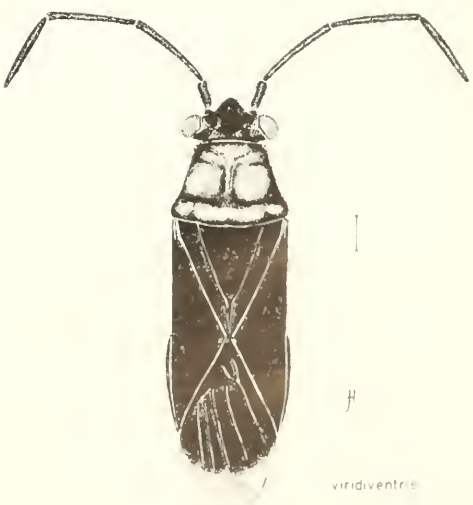


Fig. 8. *Astacops viridiventris* Stål, dorsal view. Scale = 1 mm.

abdominal terga II to VI; transverse fascia, broadest medially, on abdominal sterna IV to VI, sometimes indicated on sternum III of male and VII of female; margin of cleft in female sternum VII; ovipositor except terga; and sometimes lateral sternal margins. The following infuscated to varying degree: apical 2/3 of clavus; corium excluding costal margin; scutellum; and sometimes distal half of fore and mid femora. Abdominal venter often suffused with green. Ocelli red. Hemelytral membrane subhyaline, dark brown basally becoming lighter until almost clear at apex.

Structure: Moderately robust; thorax finely granulate, subshining, rest of body and appendages shining. Head moderately declivent; narrower across eyes than is base of pronotum; vertex slightly depressed; a low subapical hump on anteclypeus; ocelli higher than vertex, about as far from eyes as from each other; eye on distinct slightly dorsally directed stalk; buccula subtriangular, most prominent medially, reaching level of front of eyes. Antennal segment I surpassing anteclypeus by half its length. Labial segment I scarcely surpassing anterior prosternal margin, II reaching posterior procoxal margin, III reaching middle of mesocoxae, IV reaching middle of metacoxae. Pronotum much higher posteriorly than anteriorly, scarcely constricted but distinctly impressed behind callus; anterior margin straight; posterior margin convex; lateral margin nearly straight; posterior lobe about three times as long as anterior lobe; callus slightly swollen; callar impression oblique, slightly sinuate, unbranched; postcallar impression with row of punctures of varying size; median carina obsolete, faintly indicated immediately behind callus; an oblique impression at posterior margin laterad of scutellum. Scutellum with well developed T-shaped median carina; lateral fovea very coarsely punctate. Hemelytra not covering abdominal dorsum laterally; costal corial margin slightly concave basally, slightly convex apically; claval commissure about 3/4 length of scutellum; veins moderately raised; membrane greatly surpassing abdomen. Thoracic sterna impunctate; posterior margins raised. Pro- and mesopleuron with dorsoventral, indistinct row of punctures behind middle. Metapleuron impunctate; posterior margin slightly sinuate, directed slightly posteroventrally; posterolateral angle not produced. Legs relatively long; femora scarcely swollen. Abdominal sternum II not covered by metapleuron; posterior margin male sternum VII concave; VII of female cleft nearly to base, posterior margin slightly concave laterally. Abdominal dorsum with paratergites III to VI separate, VII aparently fused with laterotergites; mediotergite IV elongate; mediotergite VII with slightly concave posterior margin, indistinctly separated from fused para- and laterotergites. Pygophore as in Figs. 55b, c; median projection well developed, narrow basally, broader apically, apex with narrow dorsal hump; well developed ridge on either side of median projection separated from projection by channel; tergum IX fused to pygophore. Clasper as in Figs. 54h-j; caudolateral lobe scarcely indicated; blade rounded in cross section, slightly curved, apically acute; shank slightly excavated, a sinuate ridge anterolaterally. Aedeagus as in Figs. 55e, f; phallotheca moderately sclerotized, dorsum slightly carinate medially; phallothecal process as in Fig. 55a, projecting dorsally; conjunctiva robust, a low lateral lobe on each side, a pair of small, conical dorsal lobes just before apex; ejaculatory res-

ervoir as in Figs. 54f, g, without basal projection; vesica basally robust, divided into two vaguely defined lobes; ring sclerite complete, elongate, broader distally; vesica apically with produced lateral flange, greatly produced at ring sclerite, forming lightly pigmented cup at apex which holds gonoporal process when retracted, a short subapical sclerotized spike on inner magin; gonoporal process short, thick, visibly covered with membrane to apex, twisted subapically; secondary gonopore slightly flared, with an irregularly bent apical process. Ovipositor as in Figs. 55d, g, h; first valvula nearly reaching apex of connecting membrane; connecting membrane of first valve pigmented, granulate, deeply notched medially, two rounded projections at base of notch; second valvula flattened, bluntly rounded apically; connecting membrane of second valve cleft nearly to base, sclerotized except at junction with valvula. Spermatheca as in Fig. 55i; short, pigmented distad of sperm pump, sinuate and with cup-shaped flange just basad of apical bulb; sperm pump bell-shaped, pigmented distally, closer to apex than base.

Measurements: Length ♂ 11.2 (10.8-11.7), ♀ 12.4 (12.0-13.0); abdominal width ♂ 3.5 (3.2-3.8), ♀ 4.0 (3.7-4.2); head length ♂ .80 (.72-.96), ♀ .88 (.60-1.04); width across eyes ♂ 2.66 (2.54-2.72), ♀ 2.86 (2.76-3.00); pronotal length ♂ 1.90 (1.74-2.16), ♀ 2.06 (1.80-2.18); pronotal width ♂ 3.41 (3.30-3.62), ♀ 3.88 (3.62-4.10); scutellar length ♂ 1.74 (1.60-1.90), ♀ 2.08 (1.90-2.20); scutellar width ♂ 1.80 (1.60-2.04), ♀ 2.12 (1.96-2.28); length antennal segments I ♂ .89 (.84-.93), ♀ .92 (.90-.95), II ♂ 2.36 (2.19-2.50), ♀ 2.33 (2.20-2.48), III ♂ 2.06 (1.93-2.18), ♀ 2.08 (1.97-2.27), IV ♂ 2.47 (2.31-2.56), ♀ 2.59 (2.46-2.78); length labial segments I ♂ 1.13 (1.06-1.20), ♀ 1.31 (1.20-1.40), II ♂ 1.13 (1.04-1.20), ♀ 1.33 (1.24-1.42), III ♂ 1.06 (.98-1.12), ♀ 1.22 (1.12-1.36), IV ♂ 1.02 (.98-1.04), ♀ 1.13 (1.06-1.20).

Comments.—*Astacops viridiventris* is easily separated from *A. doddi,* the only other Australian member of the genus by the characters given in the key. Scudder (1963) provides a key to the genus including the two Australian species and gives a short discussion of their diagnostic characteristics. Occasional individuals have the pronotum completely orange or lack the transverse fasciae of the abdominal venter. Teneral specimens may be completely orange except the eyes and abdomen.

Nothing is known of the biology or food preferences of *Astacops viridiventris.* Its range in Australia is restricted to the Cape York Peninsula (Fig. 7b). Adults have been collected throughout the year.

Astacops doddi *Scudder 1963*

Figures 7b; 54a-e.

Astacops doddi Scudder, 1963:342.

Type.—Holotype ♂, "Cairns, 1920, A. P. Dodd, ex scrub" in ANIC.

Redescription.—Color: Red, tinged with orange. The following infuscated: apical half of costal corial margin; gular area; and antennal segment I distally. The following black: pronotum except anterior margin; scutellum; thoracic sterna except anterior prosternal margin; and thoracic pleura except anterior propleural margin, lateral and posterior metapleural margins, acetabulae, and ostiolar peritreme. Posterior pronotal lobe, pro- and mesopleura suffused with red. The following orange: anterior prothoracic, propleural, and prosternal margins; base of costal corial margin; acetabulae; and lateral

and posterior metapleural margins. Legs except apical half of femora dark brown to black. Antennal segments II and III dark brown to black. Antennal segment IV and ostiolar peritreme light brown. Eye and labium dark brown. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming progressively lighter until almost transparent at apex, a pale mark at basal angle.

Structure: Very similar to *A. viridiventris,* differs as follows. Robust, thorax and gular area pruinose. Head with prominent anteclypeal bump. Labial segment I surpassing anterior prosternal margin, II reaching posterior half of procoxa, III reaching mesocoxa, IV reaching metacoxa. Pygophore with median projection narrower apically and with apical bump obsolete. Clasper as in Figs. 54c-e; shorter, more robust, more broadly rounded caudolaterally, apex of blade blunt. Aedeagus with phallothecal process slightly less produced; ejaculatory reservoir as in Figs. 54a, b; gonoporal process slightly longer and thinner.

Measurements: Holotype ♂. Length 11.4; abdominal width 3.7; head length .93; width across eyes 2.92; pronotal length 2.04; pronotal width 3.70; scutellar length 1.68; scutellar width 1.84; length antennal segments I .76, II 2.54, III 2.33, IV 2.45; length labial segments I 1.28, II 1.25, III 1.33, IV 1.04.

Comments.—Astacops doddi is known only from the holotype male. It is easily separated from *A. viridiventris* by the characters given in the key.

Scopiastella Slater

Scopiastes s.g. *Xestonotellus* Horváth, 1914:629 (nom. preocc.).

Scopiastes s.g. *Scopiastella* Slater, 1957: 36; Scudder, 1963:371-372; Slater, 1964*a*:191-192; Blöte, 1972:411.

Type-species *Scopiastes cruentus* Horváth 1914 (fixed by Slater, 1957).

Diagnosis.—Eye distinctly stalked; head across eyes at least as wide as base of pronotum; antennal segment I surpassing anteclypeus by ½ to ⅔ its length; buccula convex anteriorly; pronotum except posterior margin and humerus finely granulate; posterior pronotal lobe only slightly higher than anterior lobe; posterior pronotal lobe with at most scattered punctures; spermatheca short, with small, basal, globular sperm pump, tube connecting sperm pump and apical bulb gradually widened distally, and apical bulb large; clasper tilted anteriorly, a distinct dorsal ridge at junction of shank and blade, caudolateral lobe well developed and subconical, and shank not or slightly excavated and bearing somewhat dorsally directed shelflike projection; conjunctiva with unpigmented lobe on each side at about middle; ejaculatory reservoir with Y-shaped basal projection; vesica expanded laterally into short process forming continuation of ring sclerite and similar but larger process distal of and at 180° to first; and gonoporal process with transparent, cupped, lateral subapical process.

Horváth (1914) erected *Xestonotellus* as a subgenus of *Scopiastes* Stål, separating it from *Scopiastes,* sensu stricto, by the impunctate or very finely punctate as opposed to heavily punctate posterior pronotal lobe. Slater (1957) pointed out that *Xestonotellus* was preoccupied and established *Scopiastella* as a new name for the subgenus. Scudder (1963) discussed the difficulty of assigning species to the subgenus on the basis of the single character on which it was based. He did not assign species to subgenera within *Scopiastes* on the ground that more than two groups

would be necessary to show relationships correctly. Blöte (1972) provided a key to the genera of stylate eyed Lygaeinae based on the "classic" generic characters which included the two subgenera of *Scopiastes*.

While agreeing with Scudder that *Scopiastes* sensu lato contains more than two natural species groups I have found that the Australian members of the group fall into two quite distinct and well defined assemblages of species. One group includes *Scopiastes degeeri* (Stål) the type species of *Scopiastes*. The other group agrees in external structure and in male and female genitalia with *Scopiastes cruentus* Horváth, the type species of *Scopiastella*. The differences between the two groups in the structure of the aedeagus, claspers, and spermathecae are particularly striking. As these structures are usually consistent within genera in the subfamily I have no hesitation in raising *Scopiastella* to generic status. It is quite likely that *Scopiastes* should be split further but as those species differing significantly from *S. degeeri* do not occur in Australia such action is beyond the scope of this study.

The following species belong to *Scopiastella: S. costalis* (Horváth); *S. cruentus* (Horváth); *S. elegans* (Distant); *S. himertos,* sp. nov.; *S. melvillensis* (Scudder); *S. militaris* (Distant); *S. nigricoronatus,* sp. nov.; *S. plagiatus* (Stål); *S. rubricinctus,* sp. nov.; *S. walkeri* (Distant); and *S. woodwardi,* sp. nov. As I have not seen all the species placed in *Scopiastes* sensu lato the list should not be considered to include all species belonging in *Scopiastella.*

The only genera of Australian Lygaeinae with which *Scopiastella* might be confused are those with distinctly stylate eyes, that is, *Astacops, Scopiastes,* and *Woodwardiastes. Astacops* differs in that its members are much larger and more robust, the posterior pronotal lobe is much higher than the anterior lobe, and the pronotum is much wider at the base than is the head across the eyes. *Scopiastes* differs in that the posterior pronotal lobe is densely and very coarsely punctate and that at most the anterior lobe and narrow anterior margin of the posterior lobe of the pronotum are finely granulate giving a dull appearance. *Woodwardiastes* differs in that the posterior pronotal lobe is moderately but very densely punctate, the first antennal segment is elongate, surpassing the anteclypeus by about $^{6}/_{7}$ of its length, and the bucculae are angulate anteriorly. The male and female genitalia of all four genera are distinctive.

Redescription.—Color: Variously, but usually brightly, patterned in red, yellow, orange, brown, and black.

Structure: Rather narrow and elongate, slightly to moderately constricted medially. Thorax except broad posterior margin and pronotal humeri and a narrow posterior metapleural margin finely granulate giving a dull appearance. Hairs except on finely granulate area a mixture of short, dense, decumbent and a few longer, semiupright hairs, these latter longer and denser ventrally. Hairs of finely granulate areas long, moderately dense, upright, longest and densest on calli. Head strongly declivent; vertex impressed in front of ocellus; eye on distinct stalk; ocelli slightly closer to eyes than to each other, higher than vertex; anteclypeus directed slightly posterad apically, sometimes with indistinct subapical bump; buccula convex and moderately prominent anteriorly, slightly concave and very low posteriorly, reaching $^{2}/_{3}$ to $^{3}/_{4}$ distance to anterior prosternal margin. Antennal segment I surpassing anteclypeus by $^{1}/_{2}$ to $^{2}/_{3}$ its length, IV

longest, III often longer than II. Labium not surpassing metacoxa; segment I thickest, II to IV progressively thinner. Pronotum subquadrate, slightly wider posteriorly than anteriorly, impressed and slightly constricted behind callar area; anterior margin straight or slightly concave; posterior margin straight or slightly convex; lateral margin slightly sinuate, slightly explanate centrally; posterior lobe impunctate or with scattered at most moderate punctation; a shallow oblique impression at posterior margin laterad of scutellum; posterior lobe often slightly impressed along posterior margin of finely granulate area in region of humerus; callus moderately swollen, often restricted anteriorly by transverse medial impression; callar impression oblique, slightly sinuate, unbranched. Scutellum subacute apically; T-shaped median carina and lateral fovea at least moderately developed. Clavus moderately rugose, coarsely granulate, not appearing dull. Corium moderately rugose, coarsely granulate, not dull; costal margin very slightly concave for basal ½, very slightly convex for apical ½; not completely covering outer laterotergites except apically. Hemelytral membrane surpassing tip of abdomen. Thoracic sterna impunctate, posterior margin raised. Thoracic pleura impunctate or punctate to varying degree; ostiolar peritreme well developed; posterior metapleural margin truncate, directed nearly dorsoventrally; posterior metapleural angle not produced, slightly rounded. Abdominal sterna without dorsolateral gland openings, II not covered by metapleuron; female VII cleft to base, rather elongate, slightly concave laterally; male VII shallowly concave. Abdominal dorsum with paratergites III to VI distinct, VII indistinctly separated from mediotergite VII; apodemes on paratergites III to VI. Pygophore subcircular in cross section; median projection well developed; tergum IX almost completely fused with base of pygophore. Clasper with well developed, subconical, caudolateral lobe; blade curved, subcircular in cross section basally, flattened and acute apically; shank canted anterad, with dorsal ridge and dorsally directed shelflike projection on interior side, flattened but not excavated on interior side. Aedeagus with lightly pigmented phallotheca ridged dorsomedially; phallothecal process low, directed dorsally; conjunctiva elongate, tubular, a dorsolateral lobe on each side at about midpoint, a low dorsal lobe over ejaculatory reservoir; ejaculatory reservoir complete, Y-shaped basal projection present; vesica basally robust, slightly coiled, produced into broad apically directed lobe near ring sclerite; ring sclerite incomplete, narrow basally, broader apically; vesica apically coiled, outer margin flanged and moderately pigmented, lateral projection just beyond (almost a continuation of) ring sclerite, larger lateral projection distad of this on other side of vesica; gonoporal process short, surrounding membrane visible almost to apex; secondary gonopore simple, lacking apical process, bearing transparent, flanged subapical process. Ovipositor with first valvula nearly reaching apex of connecting membrane; connecting membrane of first valve deeply cleft medially, pigmented but not sclerotized; second valvula rather flat, scarcely curved inwards apically; membrane connecting second valve almost entirely sclerotized, deeply cleft medially. Spermatheca with very short, unpigmented, basal tube; sperm pump small, rather globular; rather short pigmented tube between sperm pump and apical bulb,

gradually widened to subapical flange; apical bulb large, pigmented.

Key to the Australian Species of Scopiastella

1. Posterior pronotal lobe yellow, sometimes suffused with orangey red; a transverse dark brown to black macula just behind calli . . . 2
1′. Posterior pronotal lobe completely or nearly completely dark brown to black 4
2. Head yellow dorsally, a subquadrate dark brown to black macula at vertex . . . *nigricoronatus,* sp. nov.
2′. Head at least partly orangey red dorsally, no dark macula at vertex 3
3. Ostiolar peritreme black . . . . . *woodwardi,* sp. nov.
3′. Ostiolar peritreme yellow . . . . . *elegans* (Distant)
4. Scutellum deep red 5
4′. Scutellum dark brown to black, sometimes light medially 6
5. Abdominal venter deep red; corium mostly black with only a narrow red costal border; northern Queensland and New Guinea . . . . . *costalis* (Horváth)
5′. Abdominal venter orange, sometimes very pale and suffused with green; corium with broad red costal margin; southern Queensland and northern New South Wales . . . . . *militaris* (Distant)
6. Hemelytra completely dark brown to black. . . . . *walkeri papuas* (Scudder)
6′. Hemelytra at least partly red. . . 7
7. Hemelytra dark brown to black with a broad transverse median fascia red; legs completely dark brown to black. . . . . *rubricinctus,* sp. nov.
7′. Hemelytra with at least corium nearly completely red or orange; legs at least partly red or orange 8
8. Propleura dark brown to black except anterolaterally; labial segment II red only at base; metafemora red on only about basal half; abdomen not infuscated. . . . . *himertos,* sp. nov.
8′. Propleura orange except on produced posterior area; labial segment II and metafemora completely orange; abdomen infuscated basally on each side . . . . . *melvillensis* (Scudder)

Scopiastella costalis *(Horváth 1914)*

Figures 9; 12a; 56a, i-k; 57d, k.

Scopiastes (Xestonotellus) costalis Horváth, 1914:630-631.

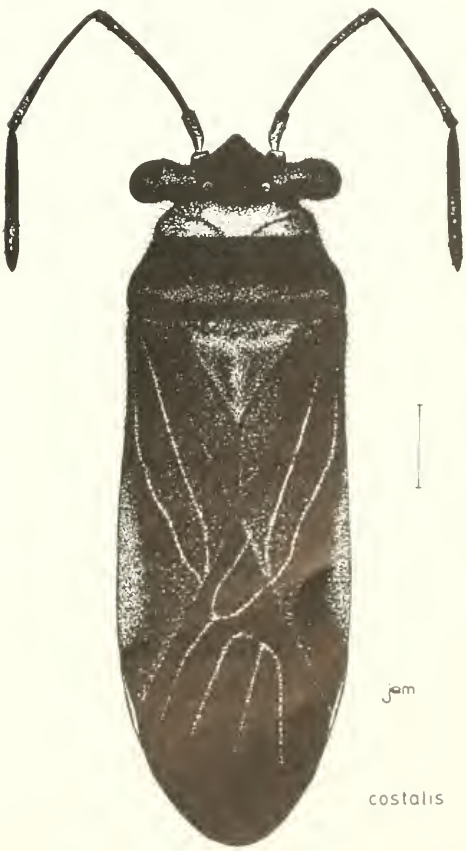


FIG. 9. *Scopiastella costalis* (Horváth), dorsal view. Scale = 1 mm.

Scopiastes costalis Scudder, 1963:378.
Scopiastes (Scopiastella) costalis Slater, 1964*a*:192.

Types.—Lectotype ♀, no locality, in Budapest. Paralectotype ♀, no locality, in Budapest.

Redescription.—Color: Head and sometimes scutellum brown suffused with red, head darker dorsally. The following dark red: anterior pronotal lobe except sometimes anterior margin; about central 1/3 of costal corial margin; sometimes scutellum; meso- and metasterna; thoracic pleura except narrow anterior margin, narrow lateral margin, broad posterior margins, and acetabulae; and abdomen. The following dark brown to black with purplish cast: posterior pronotal lobe except posterior margin and humerus; sometimes anterior pronotal margin; clavus; corium except central 1/3 of costal margin; margins of thoracic pleura; prosternum; antenna; labium except segment I; and legs except coxae. The following brown: posterior pronotal margin; humeral angle of pronotum; coxae; labial segment I; eye; and ostiolar peritreme. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming paler apically. Dark pronotal areas except posterior margin and humerus of pronotum pruinose.

Structure: Robust, rather strongly constricted at middle. Head very strongly declivent; anteclypeal bump only slightly produced. Antennal segment I surpassing anteclypeus by about 2/3 its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching posterior margin of procoxa, III reaching about anterior 2/3 of mesosternum, IV reaching or slightly surpassing posterior margin of mesocoxa. Pronotum impressed near humerus at posterior margin of granulate area; shallowly, distinctly punctate anterior of callus; postcallar impression moderately punctate; scattered punctures on posterior lobe. Scutellum with T-shaped median carina moderately developed, upright and crossbar about equally thick and high. Hemelytral membrane slightly surpassing apex of abdomen. Propleuron impunctate on margins; indistinctly punctate centrally; moderately but distinctly punctate immediately anterior and posterior of center. Mesopleuron indistinctly punctate except moderately but distinctly punctate just behind center and impunctate along lateral and posterior margins and on acetabula. Metapleuron indistinctly punctate except impunctate acetabula and evaporative area surrounding ostiolar peritreme. Pygophore very slightly concave posteriorly; apex as in Fig. 56a, median projection subacute apically. Clasper as in Figs. 56i-k; dorsal ridge and lateral projection well developed. Aedeagus similar to that of *S. nigricoronatus* (Fig. 58e). Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57d. Spermatheca as in Fig. 57k.

Measurements: 2♂, 2♀. Length ♂ 7.4, 7.7, ♀ 8.3, 8.4; abdominal width ♂ 2.7, 2.7, ♀ 2.5, 2.8; head length ♂ .50, .63, ♀ .65, .65; width across eyes ♂ 2.28, 2.35, ♀ 2.50, 2.51; pronotal length ♂ 1.18, 1.33, ♀ 1.38, 1.53; pronotal width ♂ 2.23, 2.30, ♀ 2.61, 2.65; scutellar length ♂ 1.11, 1.13, ♀ 1.23, 1.25; scutellar width ♂ 1.25, 1.35, ♀ 1.50, 1.50; length antennal segments I ♂ .52, .52, ♀ .59, .61, II ♂ 1.41, 1.42, ♀ 1.49, 1.57, III ♂ 1.40, 1.42, ♀ 1.48, 1.54, IV ♂ 1.86, 1.87, ♀ 1.73, 1.90; length labial segments I ♂ .71, .73, ♀ .79, .83, II ♂ .65, .68, ♀ .78, III ♂ .53, .55, ♀ .63, IV ♂ .58, .60, ♀ .68.

Comments.—*Scopiastella costalis* is very similar to *S. militaris* with which it

forms a north-south species pair. In addition to the characters given in the key the two species differ in the structure of the clasper and the apex of the second valvula. *Scopiastella militaris* is more strongly punctate. The two species are more robust than other Australian members of the genus.

The spermatheca figured has the margin of the subapical flange rolled. As other species in this and related genera show considerable within species variation in development of this flange this condition may not be typical of the species. The range in Australia is restricted to the far north (Fig. 12a) and it also occurs in New Guinea.

Scopiastella elegans *(Distant 1918)*

Figures 10; 56d, o-q; 57b.

Scopiastes elegans Distant, 1918:418; Scudder, 1963:380-381 (part); Slater, 1964*a*:190; Slater, 1978:856.

Types.—Lectotype ♀, "Kuranda, F. P. Dodd. Mch. '04." in BMNH. Paralectotypes: 2♂, 1♀, same locality as lectotype, "April 04." in BMNH.

Redescription.—Color: The following yellow tinged with orange: head ven-

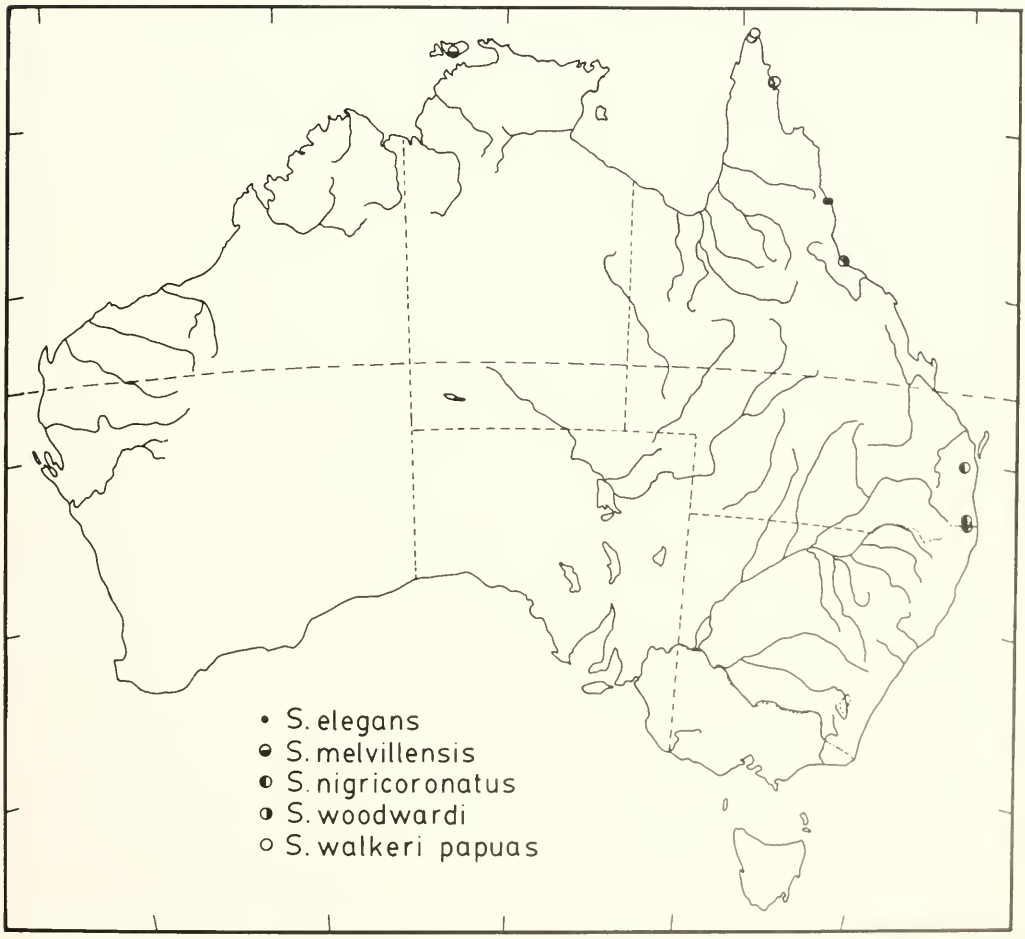


Fig. 10. Distribution of *Scopiastella elegans* (Distant), *S. melvillensis* (Scudder), *S. nigricoronatus*, sp. nov., *S. woodwardi*, sp. nov., and *S. walkeri papuas* (Scudder) in Australia.

trally and sometimes laterally; anterior pronotal lobe; posterior pronotal lobe except transverse postcallar macula, humerus, and usually posterior margin; prosternum; propleuron except rounded central macula; posterior margin and acetabula of mesopleuron; metapleuron except oblong posterior macula; abdomen; base of antennal segment I; coxae; and trochanters. The following light red: head dorsally and sometimes laterally; ocellus; humerus; usually posterior pronotal margin; clavus; corium; labial segment I; and profemur. The following dark brown to black: transverse, oblong, postcallar macula, not reaching lateral margin of pronotum; scutellum; meso- and metasterna; rounded central propleural macula; mesopleuron except posterior margin and acetabula; oblong macula near posterior margin of metapleuron, not including ostiolar peritreme; and meso- and metafemora. The following brown: antenna beyond base of segment I, lightest on segment IV; labial segments II to IV; tibiae; tarsi; and eye. Clavus infuscated apically. Hemelytral membrane subhyaline, brown basally becoming almost clear apically.

Structure: Narrow, elongate, scarcely constricted medially. Head moderately strongly declivent; anteclypeal bump moderately developed. Antennal segment I surpassing anteclypeus by about ½ its length. Labial segment I surpassing anterior prosternal margin by about ¼ its length, II slightly surpassing procoxa, III reaching mesocoxa, IV reaching metacoxa. Pronotum with a few indistinct punctures anterior of callus; postcallar impression moderately punctate; posterior lobe with few scattered moderately coarse punctures, most numerous along posterior margin of postcallar macula. Scutellum with T-shaped carina moderately swollen, upright and crossbar about equally high and thick; lateral fovea well developed, strongly punctate. Hemelytral membrane greatly surpassing tip of abdomen. Propleuron indistinctly punctate centrally; moderately but distinctly punctate immediately anterior to and posterior of center. Mesopleuron indistinctly punctate except moderately punctate just behind center and impunctate along lateral and posterior margins and on acetabula. Metapleuron indistinctly punctate except impunctate on acetabula and evaporative area. Pygophore convex posteriorly; apex as in Fig. 56d; median projection blunt apically, thickened dorsally. Clasper as in Figs. 56o-q; dorsal ridge well developed, especially posteriorly; lateral projection well developed, directed slightly posteriorly, close to dorsal ridge. Aedeagus similar to *S. nigricoronatus* (Fig. 58e). Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57b, apical projection short. Spermatheca similar to *S. costalis* (Fig. 57k).

Measurements: 3♂, 4♀. Length ♂ 6.6 (6.4-7.0), ♀ 7.2 (6.8-7.6); abdominal width ♂ 1.8 (1.7-1.8), ♀ 2.0 (1.9-2.1); head length ♂ .56 (.48-.65), ♀ .59 (.52-.68); width across eyes ♂ 2.13 (2.08-2.16), ♀ 2.32 (2.13-2.44); pronotal length ♂ 1.12 (1.08-1.21), ♀ 1.24 (1.13-1.34); pronotal width ♂ 1.87 (1.80-1.94), ♀ 2.10 (1.96-2.21); scutellar length ♂ .87 (.84-.90), ♀ .96 (.90-1.02); scutellar width ♂ 1.05 (1.00-1.11), ♀ 1.16 (1.12-1.24); length antennal segments I ♂ .43 (.41-.47), ♀ .45 (.42-.47); II ♂ 1.38 (1.34-1.41), ♀ 1.36 (1.29-1.41), III ♂ 1.47 (1.39-1.54), ♀ 1.52 (1.41-1.72), IV ♂ 1.66 (1.60-1.71), ♀ 1.68 (1.59-1.79); length labial segments I ♂ .71 (.70-.74), ♀ .78 (.75-.80), II ♂ .67 (.65-.69), ♀ .72 (.71-.76), III ♂ .57 (.56-.58), ♀ .60

(.58-.61), IV ♂ .65 (.62-.68), ♀ .68 (.66-.70).

Comments.—*Scopiastella elegans* is very similar to both *S. nigricoronatus,* with which it forms a north-south species pair, and *S. woodwardi* in general appearance. The three species differ from all known members of the genus in possessing a pale pronotum with a dark brown to black postcallar macula. *Scopiastella elegans* may be easily separated from the other two species by the combination of yellow ostiolar peritreme and head red dorsally.

The lectotype is listed as a male by Slater (1978) due to a typographical error. The specimens recorded by Scudder (1963) from Mt. Tamborine, Monteville, and National Park, Queensland, belong to *S. nigricoronatus* n. sp. Its range seems to be restricted to northern Queensland (Fig. 10) with most specimens known from the type locality.

Scopiastella himertos, *sp. nov.*

Figures 11; 12a; 57f.

Type.—Holotype ♀, "Koumala, Queensland, 18-V-1927" in QM.

Description.—Color: The following orangey red: head except U-shaped dorsal mark; anterior pronotal lobe; corium except claval and apical margins; abdomen; base of antennal segment I; labial segment I; base of labial segment II; coxae; trochanters; and femora except apex of metafemur. The following dark brown to black: U-shaped dorsal mark of head; posterior lobe of pronotum; scutellum; clavus; claval and apical margins of corium; thoracic sterna except anterior and posterior prosternal margins; thoracic pleura except anterior margin of propleuron and all acetabulae; antennal segment I except base; labial segments II and III except base of II; apex of metafemur; tibiae; and tarsi. The following pale orange: anterior and posterior prosternal margins; anterior propleural margin; and acetabulae. Eye and ostiolar peritreme brown. Ocellus red. Hemelytral membrane subhyaline, basal angle whitish, other-

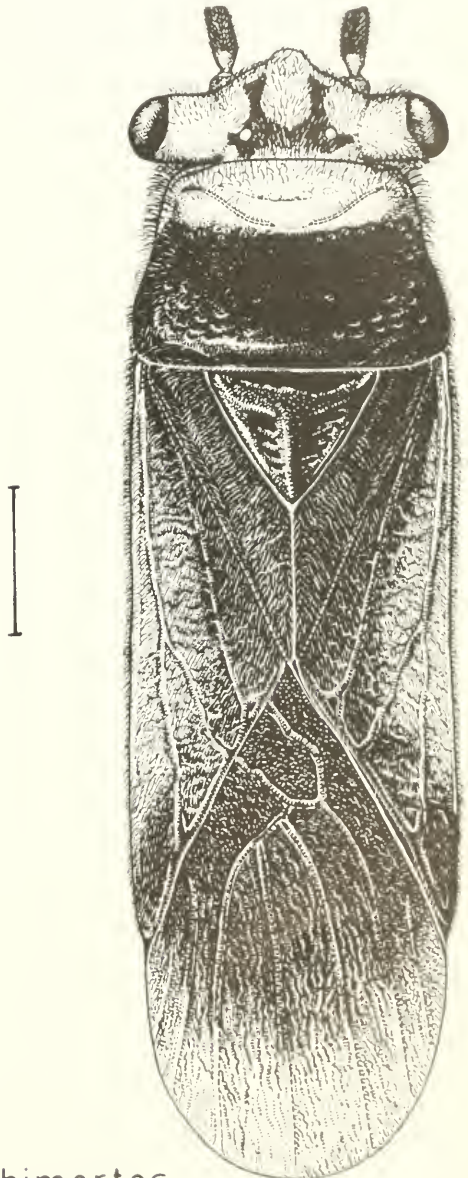


FIG. 11. *Scopiastella himertos,* sp. nov., dorsal view. Scale = 1 mm.

wise dark brown basally becoming almost clear apically.

Structure: Moderately robust, scarcely constricted medially. Head moderately strongly declivent; anteclypeal bump moderately developed. Antennal segment I surpassing anteclypeus by about ½ its length. Labial segment I surpassing anterior prosternal margin by about ⅓ its length, II slightly surpassing procoxa, III reaching metacoxa, IV absent. Pronotum with a few coarse shallow punctures anterior of callus; postcallar impression finely, distinctly punctate; posterior lobe with few scattered punctures, strongest and most numerous near humerus at posterior margin of granulate area. Scutellum with well developed T-shaped carina, upright and crossbar equally developed; lateral fovea well developed, strongly punctate. Hemelytral membrane scarcely surpassing apex of abdomen. Propleuron moderately strongly punctate centrally, otherwise impunctate. Mesopleuron moderately punctate anteriorly, impunctate posteriorly. Metapleuron with a few indistinct, scattered, punctures. Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57f, notched shallowly, produced strongly dorsally. Spermatheca similar to *S. costalis* (Fig. 57k).

Measurements: Holotype ♀. Length 7.7; abdominal width 2.3; head length .70; width across eyes 2.29; pronotal length 1.39; pronotal width 2.24; scutellar length 1.10; scutellar width 1.31; length antennal segment I .48, II to IV missing; length labial segments I .78, II .73, III .63, IV missing.

Comments.—*Scopiastella himertos* is similar to *S. melvillensis* in coloration but is larger, darker, and the abdomen is not infuscated basally. The apex of the second valvula is very distinctive.

The holotype is the only specimen known to me. It lacks labial segment IV and all antennal segments except segment I of the right antenna.

Scopiastella melvillensis
(Scudder 1963)

Figures 10; 57h.

Scopiastes melvillensis Scudder, 1963:387.

Type.—Holotype ♀, "Mellville Island, Northern Territory, W. D. Dodd" in SAM.

Redescription.—Color: The following bright orange: head; anterior lobe of pronotum; apex of clavus; corium except extreme base and apical margin; prosternum centrally; propleuron except anterior margin and produced posterior area; abdomen; base of antennal segment I; labial segments I and II; coxae; trochanters; and femora except extreme apex of metafemur. The following dark brown to black: posterior pronotal lobe; scutellum; base of clavus; extreme base and narrow apical margin of corium; meso- and metapleura except acetabulae; antennal segments I and II except base of I; and labial segments III and IV. Extreme apex of metafemur, tibiae, and tarsi light brown. Produced posterior area of propleuron, meso- and metasterna, and abdominal venter on each side at base infuscated. Anterior and posterior prosternal margins, anterior propleural margin, and acetabulae pale orange. Eye brown. Ocellus red. Hemelytral membrane subhyaline, basal angle whitish, otherwise dark brown basally becoming paler apically.

Structure: Rather short, moderately robust. Head moderately strongly declivent; anteclypeal bump scarcely developed. Antennal segment I surpassing anteclypeus by slightly more than ½ its length. Labial segment I surpassing anterior prosternal margin

by about ⅓ its length, II slightly surpassing procoxa, III almost reaching mesocoxa, IV reaching metacoxa. Pronotum with a few indistinct punctures along postcallar impression, otherwise impunctate. Scutellum with upright of T-shaped carina low, very broad, crossbar narrower and slightly higher; lateral fovea shallow, moderately coarsely punctate. Hemelytral membrane slightly surpassing apex of abdomen. Thoracic pleura impunctate. Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l; apex of second valvula as in Fig. 57h; very narrow, acute apically. Spermatheca similar to that of *S. costalis* (Fig. 57k).

Measurements: Holotype ♀. Length 6.9; abdominal width 2.0; head length .65; width across eyes 2.24; pronotal length 1.21; pronotal width 2.05; scutellar length .88; scutellar width 1.08; length antennal segments I .48, II 1.21, III, IV and apex of II missing; length labial segments I .78, II .71, III .59, IV .69.

Comments.—Scopiastes melvillensis is somewhat similar to *S. himertos* but is smaller and generally lighter in color. The shape of the apex of the second valvula is very distinctive. The species is known only from the holotype female which lacks the left antenna, the right antenna except segment I and most of segment II, and the left hemelytron. The specimen is also slightly distorted by the pin.

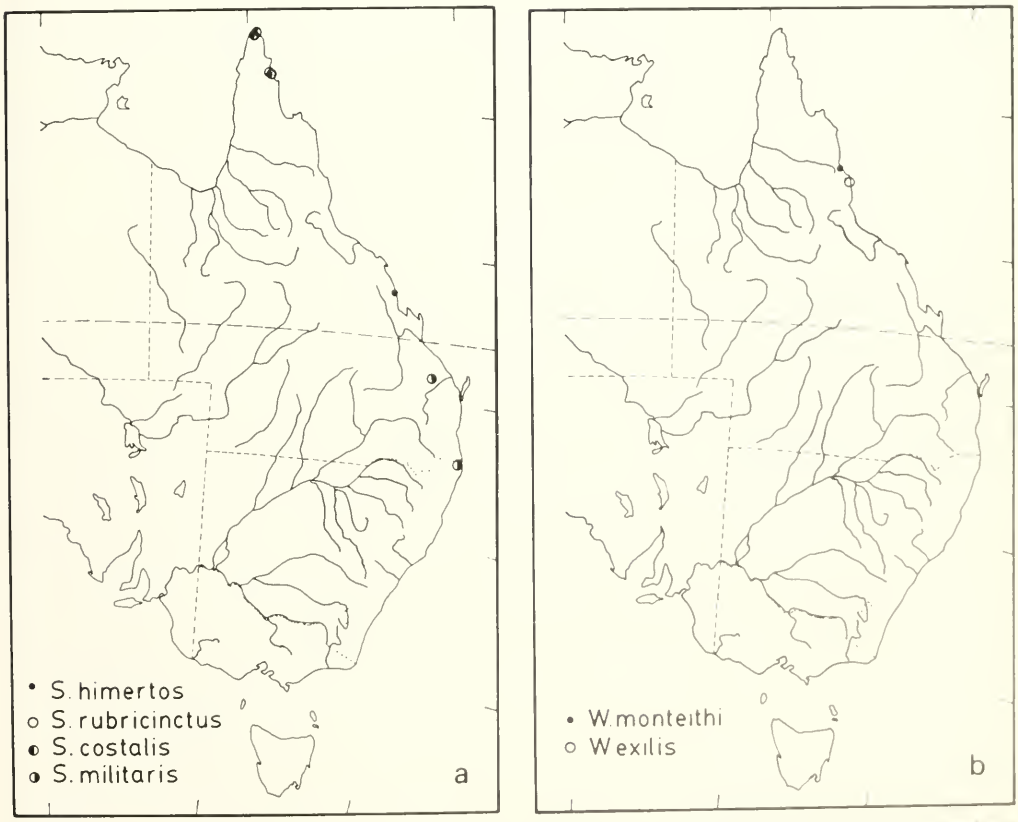


Fig. 12. a. Distribution of *Scopiastella himertos*, sp. nov., *S. rubricinctus*, sp. nov., *S. costalis* (Horvath), and *S. militaris* (Distant) in Australia. b. Distribution of *Woodwardiastes exilis*, sp. nov. and *W. monteithi*, sp. nov.

Scopiastella militaris *(Distant 1901)*

Figures 12a; 56b, f-h; 57e, m; 58a, b, g, h.

Scopiastes militaris Distant, 1901*a*:534; Scudder, 1963:387-388; Slater, 1964*a*:191.

Type.—Type ♀, "Queensland" in BMNH.

Redescription.—Color: The following dark red: head except broad longitudinal dorsal vitta; labial segments I to III; anterior pronotal lobe; scutellum; corium except broad claval and apical margins; propleuron lateromedially; mesopleuron anteriorly; metapleuron centrally; mesosternum anteriorly and laterally; and coxae. Head dorsally, labial segments, and coxae darker than rest. The following black with purplish cast: broad longitudinal dorsal vitta on head; posterior pronotal lobe; clavus; broad claval and apical margins of corium; pro- and metasterna; mesosternum centrally and posteriorly; propleuron except lateromedially; mesopleuron posteriorly; metapleuron except center; antenna; labial segment IV; and legs beyond coxae. Abdomen bright orange, sometimes lighter and suffused with green. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Robust, rather strongly constricted at middle. Head very strongly declivent; anteclypeal bump only slightly produced. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I just surpassing anterior prosternal margin, II slightly surpassing procoxa, III at most reaching mesocoxa, IV reaching metacoxa. Pronotum coarsely, shallowly punctate anterior of callar area; posterior lobe slightly impressed near humerus at posterior margin of granulate area; postcallar impression moderately punctate; posterior lobe sparsely, moderately finely punctate. Scutellum with moderately well developed T-shaped carina, upright thicker and slightly higher than crossbar; lateral fovea shallow, distinctly punctate. Hemelytral membrane slightly surpassing apex of abdomen. Propleuron moderately punctate centrally, more strongly punctate just anterior and posterior to center. Meso- and metapleura slightly less punctate than center of propleuron. Pygophore as in Figs. 58a, b; apex as in Fig. 56b; median projection subacute apically, convex and somewhat thickened dorsally. Clasper as in Figs. 56f-h; dorsal ridge low; blade rather thin. Aedeagus similar to *S. nigricoronatus* (Fig. 58e); ejaculatory reservoir as in Figs. 58g, h. Ovipositor similar to *S. nigricoronatus;* apex of second valvula as in Fig. 57e. Spermatheca as in Fig. 57m.

Measurements: 1♂, 1♀. Length ♂ 7.9, ♀ 8.6; abdominal width ♂ 2.7, ♀ 2.9; head length ♂ .53, ♀ .56; width across eyes ♂ 2.49, ♀ 2.53; pronotal length ♂ 1.23, ♀ 1.43; pronotal width ♂ 2.40, ♀ 2.54; scutellar length ♂ 1.41, ♀ 1.43; scutellar width ♂ 1.48, ♀ ?; length antennal segments I ♂ .59, ♀ .60, II ♂ 1.67, ♀ 1.62, III ♂ 1.53, ♀ 1.55, IV ♂ 1.61, ♀ 1.65; length labial segments I ♂ .73, ♀ .78, II ♂ .71, ♀ .75, III ♂ .53, ♀ .58, IV ♂ .66, ♀ .68.

Comments.—This species is very similar to *S. costalis* with which it forms a north-south species pair. The posterior pronotal lobe is more evenly punctate than in other members of the genus. The range is apparently restricted to southeastern Queensland and northeastern New South Wales (Fig. 12a).

Scopiastella nigricoronatus, *sp. nov.*

Figures 10; 13; 56e, l-m; 57c, j, l; 58e.

Scopiastes elegans Scudder, 1963 (*nec* Distant):380-381 (part).

Types.—Holotype ♂, "Queensland, Monteville, E. Bumigan, 13-I-1927" in QM. Paratypes: 1♂, same data as holotype, in QM; 1♀, "National Park, XII-1923, H. Hacker"; 1♀, "Tamborine, 27-I-1965, I. D. Galloway"; 1♀, "Wratten's Camp via Widgee, 700 meters, 28-III-1975/16-VI-1976, G. B. & S. R. Monteith"; 1♂ "Killarney, 1-XI-1932, H. Hacker" in QM, UQ, and DPI.

Description.—Color: The following yellow, sometimes suffused with orange: head except apex of anteclypeus and large subquadrate macula on vertex; pronotum except transverse postcallar macula and lateral margins of posterior lobe; prosternum; posterior margins of meso- and metasterna; pro- and mesopleura except central macula; metapleuron except posterior macula; abdomen; base of antennal segment I; labial segment I; coxae; and trochanters. The following brown to black: apex of anteclypeus; subquadrate macula on vertex of head; oblong transverse postcallar macula, not reaching lateral pronotal margin; scutellum; meso- and metasterna except posterior margins; rounded central macula on propleuron; oblong central mesopleural macula, sometimes narrowly connected to mesosternum; oblong macula near posterior margin of metapleuron, not including ostiolar peritreme; eye; antenna except base of segment I; labial segments II to IV; and legs beyond trochanters. Lateral margin of posterior pronotal lobe reddish. Ocellus, clavus, and corium except broad costal margin infuscated, sometimes heavily. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: Elongate, narrow, scarcely constricted medially. Head moderately strongly declivent; anteclypeal bump moderately developed. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I surpassing anterior prosternal margin by about ¼ its length, II slightly surpassing procoxa, III reaching mesocoxa, IV reaching metacoxa. Pronotum with indistinctly punctate postcallar impression; a few scattered, moderately coarse, punctures on posterior lobe, most numerous and deepest along posterior margin of postcallar macula. Scutellum with moderately developed T-shaped carina, upright thick

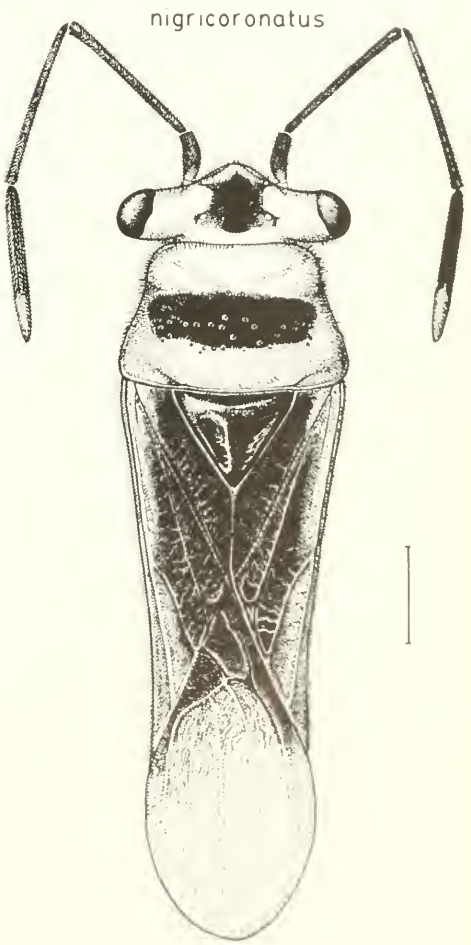


FIG. 13. *Scoptastella nigricoronatus*, sp. nov., dorsal view. Scale = 1 mm. (S. R. Monteith del.)

as but slightly lower than crossbar; lateral fovea well developed, strongly punctate. Thoracic pleura with a few scattered indistinct punctures. Pygophore convex posteriorly; apex as in Fig. 56e; median projection high, subacute apically, thickened dorsally. Clasper as in Figs. 56l-n; dorsal ridge well developed; lateral projection short, distant from dorsal ridge. Aedeagus as in Fig. 58e. Ovipositor as in Figs. 57j, l; apex of second valvula as in Fig. 57c, apical projection moderately long. Spermatheca similar to *S. costalis* Fig. 57k.

Measurements: 3♂, 3♀. Length ♂ 7.1 (6.6-7.5), ♀ 8.1 (8.0-8.2); abdominal width ♂ 1.8 (1.7-1.9), ♀ 2.1 (2.1-2.2); head length ♂ .70 (.65-.79), ♀ .80 (.71-.84); width across eyes ♂ 2.15 (2.04-2.26), ♀ 2.40 (2.36-2.45); pronotal length ♂ 1.24 (1.14-1.36), ♀ 1.44 (1.40-1.48); pronotal width ♂ 1.95 (1.83-2.05), ♀ 2.34 (2.25-2.36); scutellar length ♂ .92 (.90-.93), ♀ 1.02 (.95-1.05); scutellar width ♂ 1.08 (1.01-1.14), ♀ 1.24 (1.20-1.28); length antennal segments I ♂ .47 (.46-.48), ♀ .49 (.48-.51), II ♂ 1.50 (1.46-1.53), ♀ 1.58 (1.53-1.64), III ♂ 1.58, ♀ 1.71, IV ♂ 1.45, ♀ 1.63 (III and IV based on one member of each sex); length labial segments I ♂ .81 (.80-.81), ♀ .91 (.89-.93), II ♂ .73, ♀ .80 (.78-.83), III ♂ .60 (.60-.61), ♀ .68 (.65-.70), IV ♂ .70 (.68-.71), ♀ .74 (.73-.75).

Measurements holotype ♂. Length 7.5; abdominal width 1.9; head length .79; width across eyes 2.26; pronotal length 1.36 pronotal width 2.05; scutellar length .93; scutellar width 1.14; length antennal segments I .48, II 1.53, III 1.58, IV 1.45; length labial segments I .81, II .73, III .60, IV .71.

Comments.—*Scopiastella nigricoronatus* is the only species with a yellow pronotum and dark postcallar macula occurring in southern Queensland. It is very similar to *S. elegans* and to *S. woodwardi* but may be separated from the former by the yellow head with dark vertex and from the latter by its yellow ostiolar peritreme. It is more robust than *S. elegans* and less so than *S. woodwardi*.

Specimens from Monteville and National Park, Queensland were listed under *S. elegans* by Scudder (1963).

Scopiastella rubricinctus, *sp. nov.*

Figures 12a; 57i.

Type.—Holotype ♀, "Queensland, Iron Range, Cape York Peninsula, 28-IV/4-V-1968, G. Monteith" in QM.

Description.—Color: The following dark brown to black: head dorsally and laterally; posterior pronotal lobe except anterior half medially and at lateral margin; scutellum; clavus; corium basally and apically; and legs. The following pale orange: head ventrally, anterior pronotal lobe; anterior half of posterior pronotal lobe medially and at lateral margin; pro- and mesosterna; and thoracic pleura. Broad, transverse median corial fascia, metasternum, and abdomen reddish orange. Eye brown. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

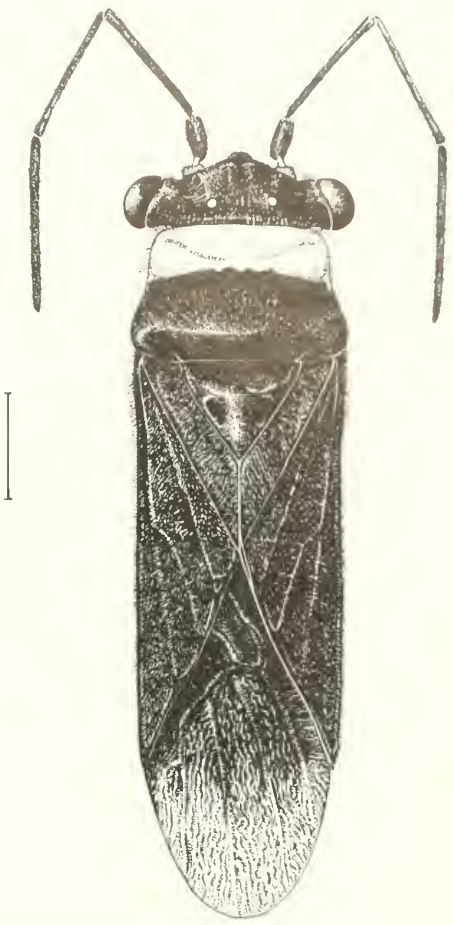
Structure: Elongate, moderately robust, slightly constricted medially. Head moderately strongly declivent; anteclypeal bump very strongly developed. Pronotum with moderately punctate postcallar impression; posterior lobe with few moderately coarse punctures near humerus along posterior margin of granulate area. Scutellum with well developed T-shaped carina, upright and crossbar thick, equally high, crossbar vaguely defined anteriorly; lateral fovea well developed, moderately coarsely punctate.

Hemelytral membrane greatly surpassing tip of abdomen. Pro- and mesopleura impunctate. Metapleuron with few indistinct punctures slightly behind center. Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57i, only slightly produced apically, with ventral hump. Spermatheca similar to *S. costalis* (Fig. 57k).

Measurements: Holotype ♀. Length 8.9; abdominal width 2.5; head length .78; width across eyes 2.59; pronotal length 1.59; pronotal width 2.50; scutellar length 1.23; scutellar width 1.38; antennae and labium missing.

Comments.—*Scopiastella rubricinctus* is named for the distinct hemelytral fascia. It is similar in general coloration to *S. cruentus* from New Guinea. That species is smaller, has red legs, has only a very narrow black apical corial margin, and has an orange head. I have seen specimens of an undescribed species from New Guinea similar to *S. rubricinctus* in size, hemelytral coloration, and leg color but with a completely orange head and black meso- and metapleura.

The holotype female is the only known specimen. It is in very poor condition. The labium, both antennae, and the right proleg are missing; the head is nearly detached, and the thorax is badly ripped ventrally. It gives one the impression that it is slightly teneral in which case the coloration of the pronotum anteriorly and the thoracic venter may be lighter than in fully mature specimens.



walkeri papuas

FIG. 14. *Scopiastella walkeri papuas* (Scudder), dorsal view. Scale = 1 mm. (S. R. Monteith del.)

Scopiastella walkeri papuas
Scudder 1963

Figures 10; 14; 56c, k, r-t.

Scopiastes walkeri papuas Scudder, 1963: 396.

Types.—Holotype ♀, "Kokoda, 400m., SE New Guinea, IV-1933, L. E. Cheesman" in BMNH. Paratypes: from various localities in New Guinea in ANIC, BMNH, Bishop, Purdue, Scudder, and Hawaiian Sugar Planter's Association collections.

Redescription.—Color: The following yellow, often suffused with orange: head laterally and ventrally; anterior pronotal lobe; prosternum; propleuron except produced posterolateral area; acetabular margins; and procoxa. The following dark brown to black: broad

median dorsal macula of head; posterior pronotal lobe; scutellum; clavus; corium; meso- and metasterna; produced posterolateral area of propleuron; meso- and metapleura except acetabular margins; antenna; labium; and legs except procoxa. Head above heavily infuscated orange except median macula. Ocellus and abdomen reddish orange, abdomen infuscated basally. Eye brown. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Short, moderately robust, scarcely constricted medially. Head very strongly declivent; anteclypeal bump strongly developed. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I slightly surpassing anterior prosternal margin, II slightly surpassing procoxa, III reaching mesocoxa, IV reaching metacoxa. Pronotum impunctate. Scutellum with low T-shaped carina, upright broad, crossbar narrow; lateral fovea shallow, moderately punctate. Hemelytral membrane slightly surpassing apex of abdomen. Thoracic pleura impunctate. Pygophore convex posteriorly; apex as in Fig. 56c; median projection subacute apically. Clasper as in Figs. 56r-t; dorsal ridge low, broadly separated from lateral projection. Ovipositor as in *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57g, rather blunt, little produced apically. Spermatheca similar to *S. costalis* (Fig. 57k).

Measurements: 1♂, 2♀. Length ♂ 6.5, ♀ 7.2, 7.5; abdominal width ♂ 1.7, ♀ 2.1, 2.3; head length ♂ .58, ♀ .62, .68; width across eyes ♂ 2.08, ♀ 2.39, 2.39; pronotal length ♂ 1.11, ♀ 1.32, 1.32; pronotal width ♂ 1.80, ♀ 2.16, 2.21; scutellar length ♂ .70, ♀ .98; scutellar width ♂ .88, ♀ 1.30; length antennal segments I ♂ .43, ♀ .47, .48, II ♂ 1.22, ♀ 1.32, 1.34, III ♂ 1.35, ♀ 1.41, 1.42, IV ♂ 1.58, ♀ 1.81, 1.86; length labial segments I ♂ .66, ♀ .79, .81, II ♂ .61, ♀ .71, .75, III ♂ .45, ♀ .58, IV ♂ .59, ♀ .66.

Comments.—*Scopiastella walkeri papuas* is the only Australian *Scopiastella* with completely dark hemelytra. The Australian specimens examined have less orange color in the light parts of the head and thorax than do those from Papua New Guinea. The blade and caudolateral lobe of the clasper are slightly more acute. It is possible that the two forms are not conspecific, but as the differences are minor, and as Scudder (1963) considered larger differences of only subspecific importance in the same species, it seems better not to split the two groups at present. Examination of a larger series from both Australia and New Guinea will be necessary to establish within species variation needed to resolve the situation.

The range in Australia includes only the Cape York Peninsula (Fig. 10). I have also examined specimens from various localities in New Guinea.

Scopiastella woodwardi, *sp. nov.*

Figures 10; 57a.

Type.—Holotype ♀, "Queensland, Forest Road, 8-15 mi. from highway, Ingham to Townsville, 20-III-1961, R. Straatman" in ANIC.

Description.—Color: Head and pronotum, except transverse postcallar macula, yellow irregularly mottled with orangey red. The following yellow: prosternum; propleuron except centrally; posterior margin and acetabula of mesopleuron; posterior and narrow lateral margin and acetabula of metapleuron; abdomen; base of antennal segment I; coxae; trochanters; and extreme bases of femora. The following

dark brown to black: transverse, oblong postcallar macula not reaching lateral pronotal margin; scutellum; clavus except apically and along margin of claval suture; meso- and metasterna; mesopleuron except posterior margin and acetabula; metapleuron except posterior and lateral margins and acetabula but including ostiolar peritreme; eye; antenna except base of segment I; labial segments II to IV; meso- and metafemora except extreme bases; tibiae; and tarsi. Corium, labial segment I, profemur, and ocellus orangey red. Clavus apically and along claval suture and apical margin, and propleuron centrally infuscated. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Elongate, narrow, nearly parallel sided. Head moderately strongly declivent; anteclypeal bump scarcely produced. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I slightly surpassing anterior prosternal margin, II slightly surpassing procoxa, III almost reaching mesocoxa, IV slightly surpassing mesocoxa. Pronotum with distinctly punctate postcallar impression, posterior lobe with a few indistinct punctures along posterior margin of postcallar macula. Scutellum with upright and crossbar of T-shaped carina narrow, crossbar indistinct anteriorly; lateral fovea well developed, very coarsely punctate. Hemelytral membrane greatly surpassing apex of abdomen. Propleuron lightly punctate centrally. Meso- and metapleura posteriorly with a few very indistinct punctures. Ovipositor similar to *S. nigricoronatus* (Figs. 57j, l); apex of second valvula as in Fig. 57a, deeply notched. Spermatheca similar to *S. costalis* (Fig. 57k).

Measurements: Holotype ♀. Length 7.6; abdominal width 2.1; head length .75; width across eyes 2.35; pronotal length 1.48; pronotal width 2.25; scutellar length .95; scutellar width 1.15; length antennal segments I .45, II 1.41 (1.79), III 1.49 (2.64), IV 1.55; length labial segments I .75, II .75, III .53, IV .64.

Comments.—*Scopiastella woodwardi* is named for Dr. T. E. Woodward who provided me with the opportunity to undertake this revision.

This species is very similar to *S. elegans* and *S. nigricoronatus*. It differs from both in possession of a black ostiolar peritreme, being slightly more robust and in the distinctly notched apex of the second valvula.

The holotype ♀ is the only known specimen. This specimen exhibits oligomery of the right antenna. Only three segments are present with the apical two elongate (figures in parentheses in the measurements section) and the basal segment unaffected. The left antenna appears normal.

Scopiastes Stål

Scopiastes Stål, 1874:98, 100; Scudder, 1963:371; Slater, 1964*a*:189; Blöte, 1972:411.

Abgarus Distant, 1910:313.

Astacops Breddin, 1901:78 (part); Bergroth, 1918:56-57 (part).

Type-species *Astacops degeeri* Stål 1865, monobasic.

Diagnosis.—Eyes stalked; head at least as wide across eyes as is pronotum at base; first antennal segment surpassing anteclypeus by about half its length; buccula convex, highest anteriorly, tapering posteriorly to about half distance to pronotal margin; pronotum with at most anterior lobe and narrow anterior margin of posterior lobe granulate; posterior pronotal lobe slightly higher than anterior lobe, densely and

strongly punctate; spermatheca moderately long, sperm pump at least moderately elongate and semi-tubular, tube connecting sperm pump and apical bulb nearly parallel sided except apically, apical bulb moderately large; shank of clasper nearly at right angle to line through basal opening, caudolateral lobe well developed, often blunt or bent, lateral projection on mesal side overhanging distinct excavation, dorsal ridge connects overhanging projection with junction of blade and shank; conjunctiva of aedeagus with bifid, pigmented dorsal lobe medially and conical subapical dorsal lobe; ejaculatory reservoir with Y-shaped basal projection; vesica robust throughout, no lateral processes; and gonoporal process without apical or subapical processes.

Scopiastes was erected by Stål (1874) who separated it from *Astacops* Boisduval by the strongly punctate pronotum, the less slender antennae, and the first tarsal segment being about equal in length to the other two segments together. Since that time Lygaeinae with stylate eyes and with characters intermediate between *Astacops* and *Scopiastes* have been discovered. As a result authors have either united the two genera or separated them on combinations of characters other than Stål's. The latest attempt to delimit *Scopiastes* is that of Scudder (1963). In his key to the genera of the "*Astacops* complex" (pp. 318-319) he lists a number of characters separating the genera. Unfortunately almost every character listed under *Scopiastes* is qualified by "usually." The only consistent character is the presence in *Scopiastes* of a "'wishbone-like' portion near entry of ducts" on the ejaculatory reservoir.

At least part of the difficulty in defining *Scopiastes* results from the inclusion within the genus of more than one group sufficiently distinct to be accorded generic status. One such group, *Scopiastella* Slater, is raised to generic status in this paper. The Australian members of *Scopiastes,* including the type species *S. degeeri* (Stål), form a homogenous and easily defined group.

Scopiastes is unlikely to be confused with any Australian Lygaeinae except those genera whose members have stylate eyes. It may be separated from *Astacops* and *Scopiastella* by the strongly, densely punctate posterior pronotal lobe and from *Woodwardiastes* by the first antennal segment surpassing the anteclypeus by only half its length and the bucculae not angulate anteriorly.

The genus contains several north-south species pairs and at least two very similar sympatric species. In contrast to the other genera with stylate eyes, some of the species appear from their distribution to be dry adapted.

Redescription.—Color: Variously patterned in red, orange, yellow, brown, and black.

Structure: Rather narrow and elongate, nearly parallel sided, very slightly constricted medially. Thoracic venter and sometimes anterior pronotal lobe finely granulate giving a dull appearance. Hairs except on callar region and vittae of abdominal venter (when present) a mixture of dense, short, semidecumbent hairs and longer, sparser, upright hairs, the former shorter and the latter longer on venter. Short decumbent hairs absent on abdominal vittae. Hairs of callar region long, upright, usually dense. Thorax and hemelytra sometimes without mixture of short decumbent and long upright hairs but rather with moderately dense, moderately long upright hairs only, sparsest on thoracic pleura. Head moderately strongly declivent, at least as wide across eyes as is pronotum across base; vertex at least slightly impressed

anterior of ocellus; eye stalked; ocellus higher than vertex, at least as far from eye as from other ocellus; anteclypeus directed slightly posterad apically, subapical bump present; buccula convex, moderately prominent anteriorly, sloping gently posteriorly, reaching about halfway to anterior prosternal margin. Antennal segment I surpassing anteclypeus by ⅓ to ½ its length, II or IV longest. Labium not surpassing metacoxa; segment I thickest, II to IV progressively narrower. Pronotum subquadrate, slightly narrower anteriorly than posteriorly, distinctly impressed and slightly constricted behind callus; anterior margin straight; posterior margin slightly convex; lateral margin slightly sinuate; posterior lobe densely, coarsely punctate, not impressed anteromedial of humerus, a shallow oblique impression at posterior margin lateral of scutellum; callus moderately swollen, impunctate; callar impression oblique, sinuate, unbranched. Scutellum bluntly rounded apically; T-shaped median carina sometimes low, always distinct; lateral fovea sometimes shallow, always distinct. Hemelytra moderately rugose at least apically on corium; granulate; not dull; not completely covering outer latertergites medially; slightly surpassing apex of abdomen. Thoracic sterna impunctate except sometimes prosternum; posterior margins raised. Thoracic pleura impunctate to strongly punctate; ostiolar peritreme well developed; posterior metapleural margin directed almost dorsoventrally; posterolateral metapleural angle not or slightly produced. Abdominal venter with segment II not covered by metapleuron; female sternum VII cleft to base, slightly concave laterally; male sternum VII slightly concave posteriorly; sterna without dorsolateral gland openings. Abdominal dorsum with paratergites III to VI distinct; paratergites VII apparently fused with mediotergite and latertergites VII; apodemes on paratergites where these distinct. Pygophore subcircular in cross section; median projection well developed; tergum IX nearly completely fused with base of pygophore. Clasper with well developed caudolateral lobe sometimes bent; blade curved, subcircular in cross section basally, flattened apically, acute; shank at right angle to base, interior side excavated with laterally projecting overhang, overhang with dorsal ridge. Aedeagus with phallotheca moderately to strongly pigmented, median dorsal ridge; phallothecal process simple, projecting slightly dorsally; conjunctiva tubular, moderately robust, at middle with bifid, pigmented dorsal lobe, connical dorsal lobe subapically, low dorsal lobe over ejaculatory reservoir; ejaculatory reservoir complete, with Y-shaped basal projection; vesica basally robust, twisted; ring sclerite incomplete, broad basally, narrowed apically; vesica apically robust, twisted, lightly pigmented along lateral margin; gonoporal process moderately long, visibly covered by membrane nearly to apex; secondary gonopore simple, without apical process. Ovipositor with first valvula almost reaching apex of connecting membrane; connecting membrane of first valve sometimes pigmented, never sclerotized, deeply cleft medially and sublaterally; second valvula produced, sometimes twisted apically; connecting membrane of second valve almost completely sclerotized, cleft medially. Spermatheca with pigmented apical bulb; tubular section connecting sperm pump and apical bulb pigmented, slightly wider and usually flanged apically; sperm pump at least moderately elongate, usually tubular, sometimes

pigmented basally; tube basal of sperm pump moderately long.

Key to the Australian Members of Scopiastes

1. Anterior pronotal lobe red, orange, or yellow 2
1′. Anterior pronotal lobe brown to black 8
2. Hemelytra unicolored, brown to black 3
2′. Hemelytra at least partly red or orange 4
3. Second antennal segment longest; scutellum at least moderately infuscated; posterior pronotal lobe as dark as hemelytra; southern Queensland and northern New South Wales . . *bicolor* Distant
3′. Fourth antennal segment longest; scutellum yellow; posterior pronotal lobe slightly paler than hemelytra; northern Queensland . . . . . *yorkensis,* sp. nov.
4. Corium completely red except sometimes extreme base and narrow apical margin 5
4′. Corium if almost completely red then with a black triangular macula at apical margin 6
5. Abdominal venter with a distinct longitudinal vitta on each side. . . . . *melampus* (Bergroth)
5′. Abdominal venter without lateral longitudinal vittae . . . . . *affinis* Distant
6. Corium with triangular black macula at apical margin; abdominal venter with distinct longitudinal vitta on each side . . . . . *degeeri* (Stål)
6′. Corium without triangular macula at apical margin; abdominal venter without lateral longitudinal vittae 7
7. Corium with an oblique, dark brown to black fascia roughly parallel to apical margin; meso- and metapleura dark brown to black . . . . . *obliquus* Scudder
7′. Corium with a broad, transverse, infuscated fascia. . . . . *facetus,* sp. nov.
8. Hemelytra completely brown to black 9
8′. Hemelytra with at least costal corial margins red or orange at base 10
9. Head yellow; longitudinal lateral vittae of abdominal venter becoming narrow and indistinct posteriorly . . . . . *scudderi,* sp. nov.
9′. Head orange; longitudinal lateral vittae of abdominal venter about as broad and distinct posteriorly as anteriorly . . . . . *turneri* Distant
10. Basal half of hemelytra dark brown to black, apical half bright orangey red; legs red with at most bases of femora infuscated 11
10′. Hemelytra variously patterned but never with basal half dark brown to black and apical half orangey red; legs brown or black except sometimes bases of femora 12
11. Abdominal venter completely dark brown to black; pro- and mesofemora lightly infuscated basally . . . . . *hackeri* Scudder
11′. Abdominal venter red laterally at base; pro- and mesofemora not infuscated basally . . . . . *kurandensis,* sp. nov.
12. Hemelytra red basally and apically, with broad transverse brown fascia medially; abdominal venter with at most a longitudinal row of small dark brown to black spots on each side . . . . . *eylandtensis* Scudder
12′. Hemelytra variously patterned but never as above; abdominal venter with a distinct, sometimes

interrupted, dark brown to black longitudinal vitta on each side . . 13

13. Anterior pronotal lobe finely granulate, appearing dull . . . . . *taroomi*, sp. nov.

13′. Anterior pronotal lobe shiny except sometimes narrow lateral margins 14

14. Clasper (Figs. 60g-i) very deeply excavated laterally, lateral projection with a ventral ridge posteriorly; apex of second valvula (Fig. 62b) very strongly produced, very strongly curved mesad; northern Queensland. . . . . *perplexus*, sp. nov.

14′. Clasper only moderately excavated laterally; lateral projection without a posterior ventral ridge; apex of second valvula at most moderately strongly produced and curved mesad; southern Queensland and northern New South Wales 15

15. Antennal segment IV longer than II; smaller (♂ 5.0-5.5, ♀ 5.6-6.3 mm long); clasper (Figs. 60m-o) with lateral projection not appearing notched apically . . . . . *impeditus*, sp. nov.

15′. Antennal segment II longer than IV; larger (♂ 5.6-6.5, ♀ 6.5-6.9 mm long); clasper with lateral projection appearing notched apically 16

16. Antennal segment II shorter (1.10 mm long); light coloration of hemelytra and legs yellowish orange; clasper (Figs. 60d-f) with caudolateral lobe not bent strongly dorsad, lateral projection not swollen subapically; south-central Queensland . . . . . *obscurus*, sp. nov.

16′. Antennal segment II longer (1.15-1.28 mm long); light coloration of head and legs reddish orange; clasper (Figs. 60a-c) with caudolateral lobe bent strongly dorsad, dorsum of lateral projection swollen subapically; southern Queensland and northern New South Wales . . . . . *laticeps* (Breddin)

Scopiastes affinis *Distant 1901*

Figure 20.

Scopiastes affinis Distant, 1901*a*:533; Scudder, 1963:374; Slater, 1964*a*: 189.

Types.—Lectotype ♂, "Western Australia, Roebuck Bay, J. J. Walker" in BMNH. Paralectotype ♂, same data as lectotype, in BMNH.

Redescription.—Color: The following bright orangey red: head; pronotum except broad posterior margin; clavus; corium; propleuron; abdominal venter except sternum VII and genital segments; base of antennal segment I; and labial segment I. The following dark brown to black: broad posterior margin of pronotum; scutellum; meso- and metapleura; abdominal sternum VII; genital segments; eye; antenna except base of segment I; labial segments II to IV; and legs. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Moderately robust. Head very strongly declivent; anteclypeal bump strongly produced; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I reaching anterior prosternal margin. Pronotum with posterior lobe very coarsely punctate. Scutellum with upright of T-shaped carina rather narrow; lateral fovea well developed, very coarsely punctate. Hemelytral membrane slightly surpassing tip of abdomen.

Measurements: Length 4.8; width

across eyes 1.73; pronotal length 1.27; pronotal width 1.82; length antennal segments I .27, II .82, III .73, IV 1.09.

Comments.—I have not seen this species. The redescription is based on excellent color slides of the dorsum and venter kindly supplied by Mr. W. D. Dolling of the BMNH. The measurements are from Scudder (1963).

Scopiastes affinis is similar in appearance to *S. melampus* but is much smaller and lacks the lateral vittae on the abdominal venter characteristic of that species. In addition to the type series Scudder lists a male from Connexion Island, Groote Eylandt, in the South Australian Museum.

Scopiastes bicolor *Distant 1901*

Figures 15; 17b; 58c, d; 60p-r; 61l; 62g, m.

Scopiastes bicolor Distant, 1901*a*:533-534; Scudder, 1963:374-375; Slater, 1964*a*:189; Slater, 1978:855-856.

Scopiastes vitticeps Horváth, 1902:603; Slater, 1964*a*:191.

Types.—Lectotype ♀ of *bicolor,* "Queensland" in BMNH. Paralectotype ♀ of *bicolor,* "Gayndah" in BMNH. Type ♀ of *vitticeps,* "Richmond" in Budapest.

Redescription.—Color: The following yellow or bright orange: head except broad dorsal vitta; anterior lobe of pronotum; pro- and metasterna; thoracic pleura except apex of ostiolar peritreme, posterior margins, and acetabulae; and abdomen except row of maculae forming interrupted vitta each side of venter and genital segments. The following dark brown to black: broad longitudinal vitta from ocellus to apex of anteclypeus; posterior lobe of pronotum; clavus; corium; mesosternum; apex of ostiolar peritreme and evaporative area; subquadrate macula

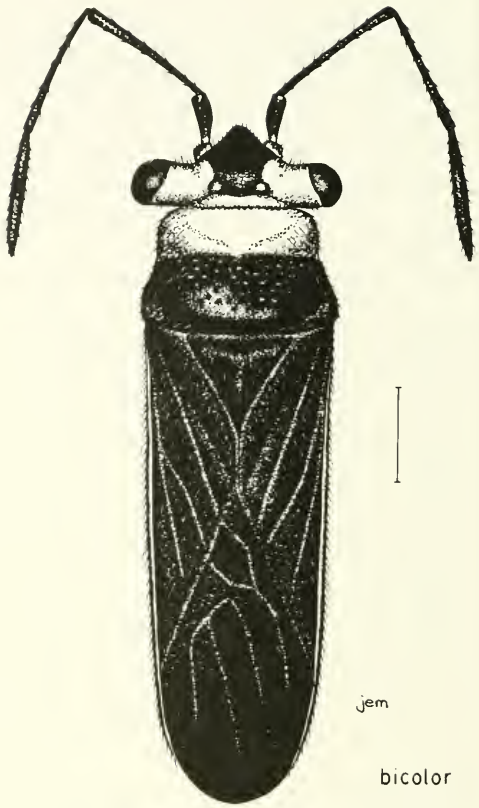


FIG. 15. *Scopiastes bicolor* Distant, dorsal view. Scale = 1 mm.

on each side of sterna III to VII, not reaching posterior margins, sometimes meeting or nearly meeting medially on sterna V to VII; genital segments; eye; antenna; labium; and legs. The following pale yellow: buccula; posterior pleural margins; acetabulae; and posterior margins of abdominal sterna. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming almost clear apically.

Structure: Moderately robust; clothed with intermixed short, decumbent and long, upright hairs. Head with moderately strongly developed anteclypeal bump; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by slightly more than ½ its length. Labial segment I slightly surpassing anterior

prosternal margin, II reaching middle of procoxa, III reaching anterior third of mesosternum, IV not or scarcely reaching mesocoxa. Pronotum moderately densely, moderately coarsely punctate except callar area and narrow posterior margin impunctate. Scutellum with upright of T-shaped carina lower than crossbar, equally thick; lateral fovea narrow, strongly punctate. Hemelytral membrane scarcely surpassing tip of abdomen. Prosternum with a few coarse, shallow punctures. Thoracic pleura indistinctly to moderately punctate except posterior margins and acetabulae impunctate. Pygophore as in Figs. 58c, d; subcircular in cross section, convex posteriorly; median projection low, blunt apically, with very thin dorsal crest. Clasper as in Figs. 60p-r; caudolateral lobe broad basally, directed slightly dorsad. Aedeagus similar to *S. degeeri* (Fig. 58f); phallotheca moderately pigmented. Ovipositor with first valve similar to *S. laticeps* (Fig. 62n); second valve as in Fig. 62m; apex of second valvula as in Fig. 62g, strongly convex laterally at apex. Spermatheca as in Fig. 61l; sperm pump short, constricted medially, pigmented basally; subapical flange variously developed, sometimes absent.

Measurements: 4♂, 10♀. Length ♂ 6.8 (6.6-7.0), ♀ 7.8 (7.2-8.3); abdominal width ♂ 2.0 (1.9-2.1), ♀ 2.3 (2.1-2.7); head length ♂ .66 (.62-.74), ♀ .71 (.63-.90); width across eyes ♂ 2.26 (2.22-2.30), ♀ 2.43 (2.31-2.58); pronotal length ♂ 1.30 (1.28-1.36), ♀ 1.46 (1.24-1.65); pronotal width ♂ 2.03 (1.99-2.09), ♀ 2.34 (2.10-2.52); scutellar length ♂ .90 (.83-.96), ♀ 1.03 (.94-1.20); scutellar width ♂ 1.09 (1.00-1.16), ♀ 1.27 (1.08-1.38); length antennal segments I ♂ .50 (.47-.52), ♀ .52 (.49-.56), II ♂ 1.54 (1.46-1.64), ♀ 1.58 (1.50-1.70), III ♂ 1.43 (1.33-1.53), ♀ 1.42 (1.23-1.51), IV ♂ 1.31 (1.20-1.41), ♀ 1.38 (1.19-1.55); length labial segments I ♂ .61 (.59-.63), ♀ .70 (.64-.78), II ♂ .59 (.58-.60), ♀ .64 (.61-.69), III ♂ .42 (.40-.45), ♀ .48 (.44-.51), IV ♂ .59 (.56-.63), ♀ .64 (.60-.68).

Comments.—Specimens of *S. bicolor* with yellow rather than orange markings are very similar in appearance to *S. yorkensis*. The two species may be separated by the characters given in the key.

The type specimens of *vitticeps* and *bicolor* differ from the majority of specimens examined in that the light markings are bright orange rather than yellow, the black abdominal maculae are larger, and they are more robust. The types of *bicolor* are only specimens examined with antennal segment IV longer than III. It is possible that the two forms are not conspecific but I can find no significant difference in the genitalia. In the absence of males with orange coloration I think it best to treat them as one species.

A female from Fletcher, Queensland, matches Scudder's (1963) description of a female in the Bishop Museum collection from Macleay River, New South Wales, in that it has the head completely black dorsally. A specimen from Tweed River, New South Wales, lacks the dark macula of the head. These specimens may also not be conspecific with the types of *bicolor* but again I can find no significant genitalic differences. All of these specimens are also females except possibly the Tweed River specimen which is lacking the abdomen.

Scopiastes degeeri *(Stål 1865)*

Figures 16a; 17b; 58f; 59f; 61g-i, m; 62k, n, o.

Astacops degeeri Stål, 1865:187.

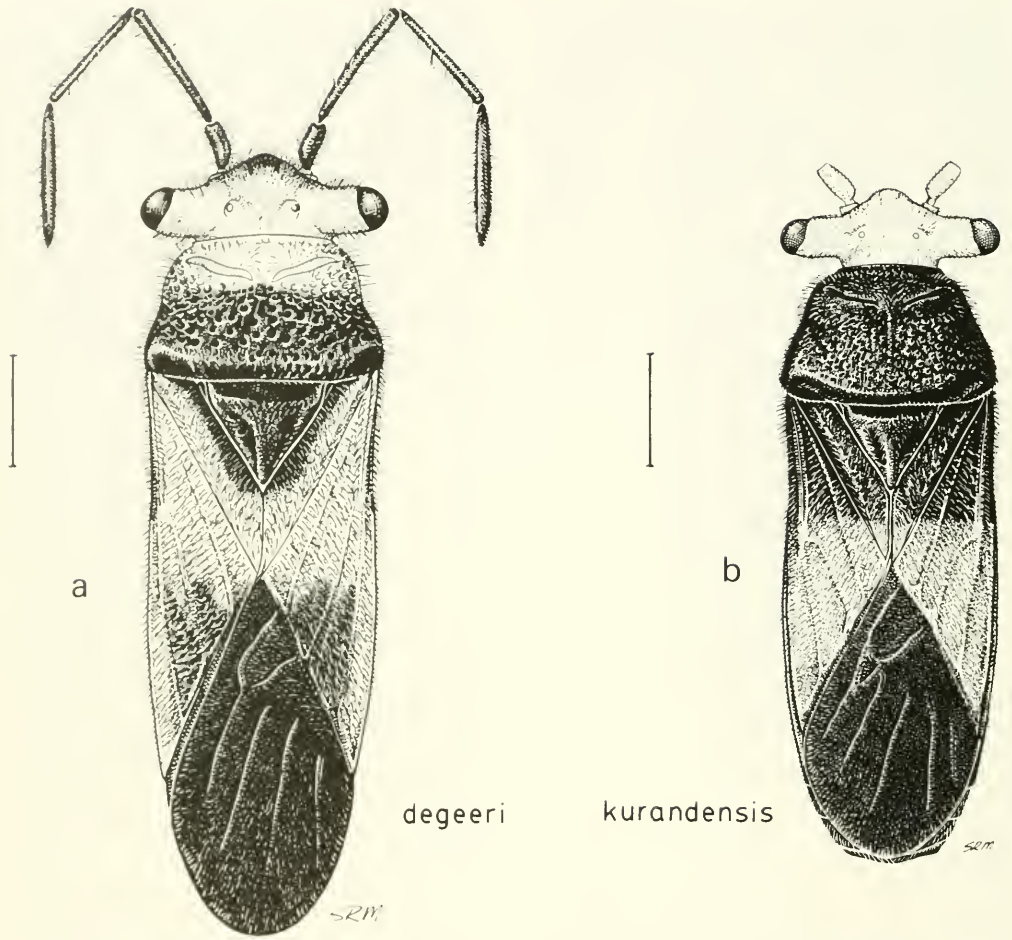


FIG. 16. a. *Scopiastes degeeri* (Stål), dorsal view. b. *Scopiastes kurandensis*, sp. nov., dorsal view. Scale = 1 mm.

Scopiastes degeeri Stål, 1874:100; Scudder, 1963:379; Slater, 1964*a*:190.

Type.—Type ♀, "Austral. boreal." "Thorey." in Stockholm.

Redescription.—Color: The following bright orangey red: head except broad dorsal vitta; anterior pronotal lobe; clavus except scutellar margin; corium except costal margin at base and triangular macula at apical margin; narrow anterior prosternal margin; propleuron except posteriorly and ventrally; abdominal venter except broad longitudinal vitta on each side from sternum II to VI, segment VII and genital segments; abdominal dorsum except tergum VII and genital segments; coxae; trochanters; extreme bases of femora; ocellus; and sometimes base of antennal segment I. The following dark brown to black with purplish cast: posterior pronotal lobe; scutellum; scutellar margin of clavus; costal margin of corium basally; triangular macula at apical margin of corium; thoracic sterna except anterior margin of prosternum; propleuron except anteriorly and dorsally; meso- and metapleura; broad longitudinal vitta on each side of abdominal venter; abdominal segment VII; genital segments; eye; antennal

segment II (sometimes I and IV); labial segment IV (sometimes I-III); metafemur except extreme base; tibiae; and tarsi. Broad vitta from ocellus to apex of anteclypeus, sometimes antennal segments I and II, sometimes labial segments I to III, and occasionally meso- and metafemora infuscated brownish red. Ocellus orange. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Robust. Clothed with moderately dense, moderately long hairs on thorax and hemelytron. Head with well developed anteclypeal bump; ocelli about 1.2 times as far from eyes as from each other. Antennal segment I surpassing anteclypeus by about 1/3 its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching about middle of procoxa, III reaching about anterior 1/3 of mesosternum, IV reaching posterior margin of mesosternum. Pronotum very strongly punctate. Scutellum with T-shaped carina rather broad, upright and crossbar equally high, lateral fovea narrow, shallow, heavily punctate. Thoracic pleura moderately, shallowly punctate, less distinctly so centrally. Pygophore convex posteriorly; apex as in Fig. 59f; median projection very strongly produced, subacute apically. Clasper as in Figs. 61g-i; lateral overhang rather high, moderately produced. Aedeagus as in Fig. 44c. Ovipositor similar to *S. laticeps* (Figs. 62n, o); apex of second valvula as in Fig. 62k. Spermatheca as in Fig. 61m; sperm pump short, rotund; subapical flange developed to varying degree.

Measurements: 2♂, 6♀. Length ♂ 6.9, ♀ 7.6 (7.0-8.0); abdominal width ♂ 2.1, 2.2, ♀ 2.5 (2.2-2.7); head length ♂ .56, .78, ♀ .78 (.64-.89); width across eyes ♂ 2.30, 2.41, ♀ 2.51 (2.28-2.74); pronotal length ♂ 1.34, 1.35, ♀ 1.54 (1.36-1.70); pronotal width ♂ 2.15, 2.35, ♀ 2.55 (2.26-2.85); scutellar length ♂ .91, 1.00, ♀ 1.10 (1.00-1.24); scutellar width ♂ 1.05, 1.25, ♀ 1.37 (1.23-1.56); length antennal segments I ♂ .44, ♀ .46 (.44-.48), II ♂ 1.32, ♀ 1.28 (1.21-1.36), III ♂ 1.13, ♀ 1.19 (1.14-1.28), IV ♂ 1.20, ♀ 1.35 (1.31-1.38); length labial segments I ♂ .63, .64, ♀ .66 (.63-.70), II ♂ .56, .58, ♀ .59 (.53-.63), III ♂ .29, .36, ♀ .39 (.35-.44), IV ♂ .45, .46, ♀ .48 (.46-.53).

Comments.—The hemelytral coloration of *S. degeeri* is similar to that of light specimens of *S. laticeps* and *S. impeditus* but both those species are less robust and have the pronotum unicolorous. A single female from New South Wales has the base of the hemelytron completely black almost to the level of the scutellar apex as does *S. hackeri*, but that species lacks the triangular macula at the apical corial margin.

Scopiastes eylandtensis *Scudder 1963*

Figures 17a; 59l, p-r.

Scopiastes eylandtensis Scudder, 1963: 381.

Type.—Holotype ♂, "Groote Eylandt, N. Territory, Australia, N. B. Tindale" in SAM.

Redescription.—Color: The following reddish orange: head except broad median vitta; clavus at base; corium at base and apical 1/3; abdomen except lateral and posterior margins of sterna II to VII; and ocellus. The following dark brown to black with purplish cast: broad longitudinal vitta from ocellus to apex of anteclypeus; pronotum; scutellum; thoracic pleura except acetabulae; thoracic sterna; antennal segments I, II, and III; labium; legs; and row of small spots on each side of abdominal venter. Eye, clavus except base, and corium except base and apex brown.

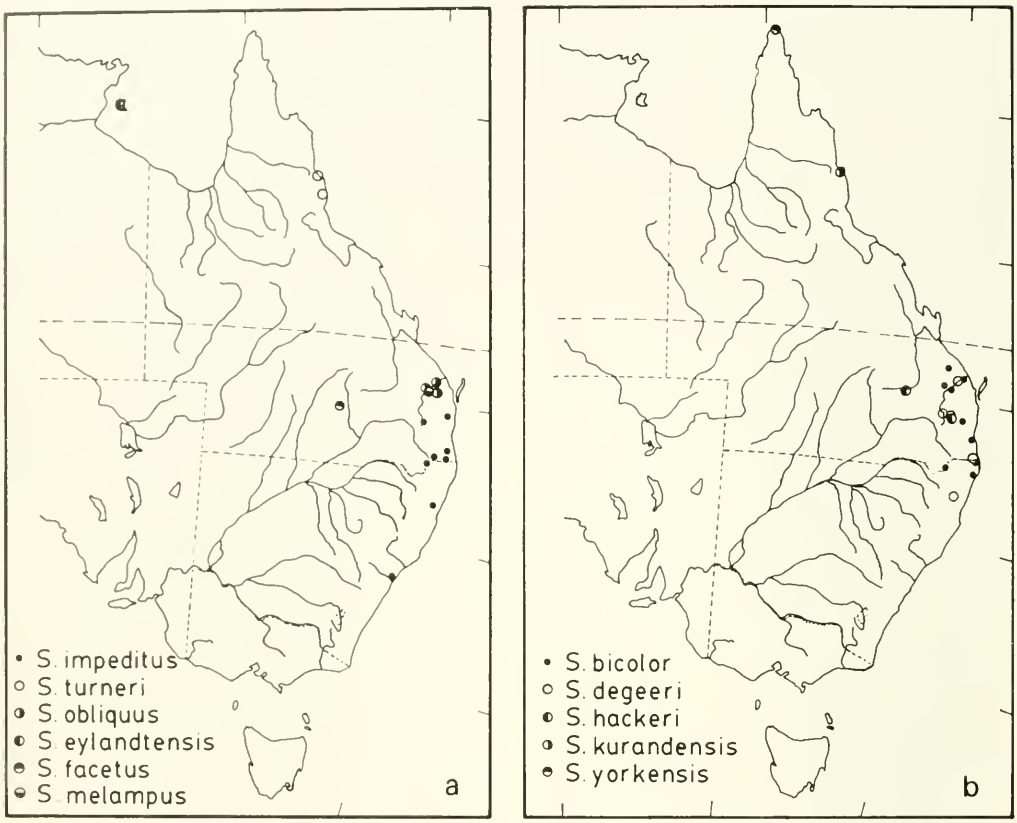


FIG. 17. a. Distribution of *Scopiastes impeditus*, sp. nov., *S. turneri* Distant, *S. obliquus* Scudder, *S. eylandtensis* Scudder, *S. facetus*, sp. nov., and *S. melampus* (Bergroth). b. Distribution of *Scopiastes bicolor* Distant, *S. degeeri* (Stål), *S. hackeri* Scudder, *S. kurandensis*, sp. nov., and *S. yorkensis*, sp. nov.

Acetabulae (narrowly) and lateral and posterior margins of abdominal sterna II to VII pale yellow. Antennal segment IV light brown. Hemelytral membrane subhyaline, dark brown basally becoming almost clear apically.

Structure: Slender. Clothed with mixture of short decumbent and very long upright hairs. Head with moderately developed anteclypeal bump; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by about ½ its length. Labial segment I slightly surpassing anterior prosternal margin, II almost reaching posterior margin of procoxa, III reaching about middle of mesosternum, IV reaching about middle of mesocoxa. Pronotum with posterior lobe deeply, moderately coarsely punctate; anterior lobe finely granulate appearing dull. Scutellum with well developed T-shaped carina; upright and cross bar equally high, equally thick; lateral fovea deep, strongly punctate. Hemelytral membrane moderately surpassing tip of abdomen. Thoracic pleura moderately punctate. Pygophore convex posteriorly; apex as in Fig. 59l; median projection short, broad, excavated apically. Clasper as in Figs. 59p-r; caudolateral lobe curved dorsad; lateral excavation broad, shallow, overhang short. Aedeagus similar to *S. degeeri* (Fig. 58f).

Measurements: Holotype ♂. Length

5.7; abdominal width 1.7; head length .55; width across eyes 1.89; pronotal length 1.00; pronotal width 1.70; scutellar length .78; scutellar width .95; length antennal segments I .38, II 1.33, III 1.08, IV 1.19; length labial segments I .63, II .58, III .38, IV .45.

Comments.—*Scopiastes eylandtensis* and *S. facetus* are the only Australian *Scopiastes* with a broad dark median fascia on the hemelytra. They are easily separated by the coloration of the pronotum, thoracic pleura, and legs.

This species is known only from the holotype.

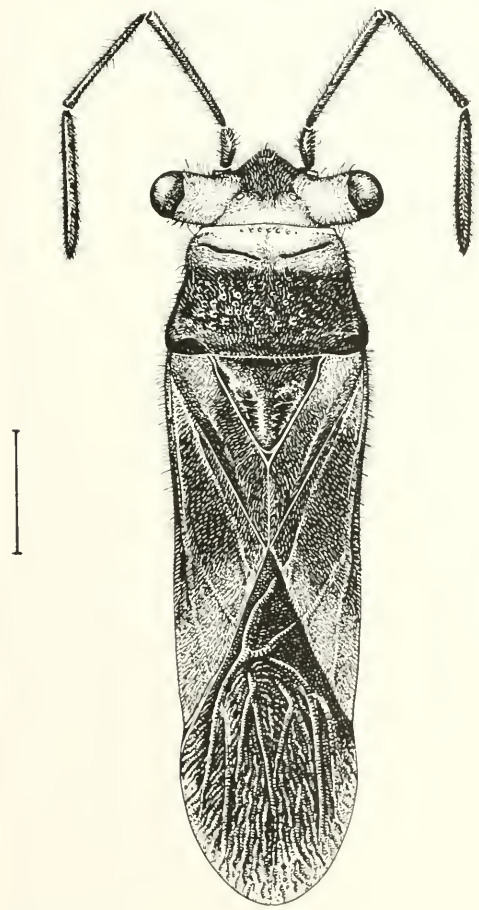


FIG. 18. *Scopiastes facetus*, sp. nov., dorsal view. Scale = 1 mm. (S. R. Monteith del.)

Scopiastes facetus, *sp. nov.*

Figures 17a; 18; 61o; 62f.

Type.—Holotype ♂, "Queensland, Morven District, IV-1941, N. Geary" in AM.

Description.—Color: The following reddish orange: head except broad longitudinal vitta; ocellus; anterior pronotal lobe; prosternum medially; propleuron medially except acetabula; and base of profemur. The following pinkish red: scutellum; clavus; corium; metasternum; mesopleuron except acetabula; metapleuron except acetabula and posterior margin; and base of mesofemur. The following infuscated: callar area; scutellum; prosternum medially; propleuron medially; and broad transverse fascia across hemelytron including about central ½ of corium and apical ½ of clavus. The following brown: posterior lobe of pronotum; mesosternum; produced posterior part of propleuron; posterior margin of metapleuron; eye; labium; coxae; and trochanters. The following dark brown to black with purplish cast: broad median vitta from ocellus to apex of anteclypeus; antenna; femora except base of pro- and mesofemora; tibiae; and tarsi. Anterior prosternal margin, anterior propleural margin, acetabulae, and abdomen pale orange. Hemelytral membrane subhyaline, dark brown basally becoming almost clear apically.

Structure: Slender. Clothed with intermixed short decumbent and very long upright hairs. Head with moderately produced anteclypeal bump; ocelli about 1.2 times as far from eyes as from each other. Antennal segment I surpassing tip of anteclypeus by about ½ its length. Labial segment I surpassing anterior prosternal margin by about ⅓ its length, II slightly surpassing procoxa, III nearly reaching

mesocoxa, IV reaching metacoxa. Pronotum with posterior lobe deeply, densely, not coarsely punctate; anterior lobe finely granulate, appearing dull. Scutellum with broad T-shaped carina, upright slightly lower than cross bar; lateral fovea shallow; strongly punctate. Hemelytral membrane slightly surpassing apex of abdomen. Prosternum very indistinctly punctate. Thoracic pleura shallowly, distinctly punctate, deepest on propleuron. Ovipositor similar to *S. laticeps* (Fig. 62n, o); apex of second valvula as in Fig. 62f, produced and curved mesad. Spermatheca as in Fig. 61o, rather short, thick; sperm pump short, tubular.

Measurements: Holotype ♀. Length 5.7; abdominal width 1.6; head length .53; width across eyes 1.93; pronotal length 1.08; pronotal width 1.71; scutellar length .73; scutellar width .96; length antennal segments I .36, II 1.14, III 1.03, IV 1.19; length labial segments I .65, II .59, III .40, IV .54.

Comments.—*Scopiastes facetus* is named for the elegance of its appearance. It is somewhat similar in appearance to *S. eylandtensis* but the latter has completely dark legs and pronotum and antennal segment II is much longer than IV. From the locality data of the only known specimen *S. facetus* appears to be adapted to more arid conditions than most members of the genus.

Scopiastes hackeri *Scudder 1963*

Figures 17b; 59j; 61d-f; 62i.

Scopiastes hackeri Scudder, 1963:381.

Type.—Holotype ♀, "Nanango Dist., Queensland, XI-1927, H. Hacker" in QM.

Redescription.—Color: The following bright scarlet: head except broad gular area and buccula; extreme apex of clavus; about apical ½ of corium except very narrow apical margin; ocellus; antennal segment I; metafemur; pro- and mesofemora apically; and tibiae. The following dark brown to black with purplish cast: gular area; buccula; pronotum; scutellum; clavus except extreme apex; basal ½ and narrow apical margin of corium; thoracic sterna; thoracic pleura; abdominal venter; antennal segments II and III; labium; coxae; and trochanters. Basal ½ of pro- and mesofemora (latter less heavily), tarsi, and sometimes apex of anteclypeus infuscated. Antennal segment IV light reddish brown. Eye brown. Hemelytral membrane subhyaline, dark brown basally becoming slightly lighter apically.

Structure: Short, moderately robust. Thorax and hemelytron clothed with moderately long, moderately dense upright hairs, sparser on thoracic pleura. Head very strongly declivent; anteclypeal bump very well developed; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching about middle of procoxa, III reaching about anterior ¼ of mesosternum, IV just reaching mesocoxa. Pronotum with lateral margin of anterior lobe finely granulate, appearing dull; posterior lobe deeply, very densely, moderately coarsely punctate. Scutellum with crossbar of T-shaped carina very broad, upright slightly narrower and lower; lateral fovea narrow, deep, coarsely punctate. Hemelytral membrane almost reaching tip of abdomen. Prosternum indistinctly punctate. Thoracic pleura moderately densely punctate, dorsolateral line of coarser, deeper punctures behind middle of each pleuron. Pygophore with posterior margin convex; apex as in Fig. 59j; median projection short, high, subacute, not produced apically, triangular appear-

ance if viewed anteriorly. Clasper as in Figs. 61d-f; caudolateral lobe subconnical, subacute apically; lateral excavation shallow, overhanging projection moderately produced. Aedeagus similar to *S. degeeri* (Fig. 58f). Ovipositor similar to *S. laticeps* (Figs. 62n, o); apex of second valvula as in Fig. 62i, bluntly produced ventrally. Spermatheca similar to *S. bicolor* (Fig. 61l).

Measurements: 1♂, 2♀. Length ♂ 6.0, ♀ 5.9, 6.6; abdominal width ♂ 2.1, ♀ 1.9, 2.4; head length ♂ .61, ♀ .50-.66; width across eyes ♂ 2.13, ♀ 2.13, 2.25; pronotal length ♂ 1.16, ♀ 1.09-1.33; pronotal width ♂ 1.98, ♀ 1.95, 2.13; scutellar length ♂ .83, ♀ .80, .83; scutellar width ♂ 1.03, ♀ 1.03, 1.09; length antennal segments I ♀ .44, .47, II ♀ 1.23, 1.34, III ♀ 1.25, IV ♀ 1.28; length labial segments I ♂ .54, ♀ .56, .56, II ♂ .53, ♀ .50, .55, III ♂ .35, ♀ .33, .39, IV ♂ .46, ♀ .43, .48.

Comments.—*Scopiastes hackeri* is somewhat similar to *S. degeeri* in coloration but lacks a triangular macula at the apical corial margin and has a completely dark abdominal venter. It is very similar to *S. kurandensis* with which it forms a north-south species pair. The two species are easily separated by the characters given in the key and by the genitalia.

The type specimen is slightly teneral with the dark areas more brown than black. It is the only specimen examined with anything resembling useful locality data. The two other specimens examined are listed only as from Queensland. It is an assumption on my part that its range is restricted to southern Queensland and probably northern New South Wales.

Scopiastes impeditus, *sp. nov.*

Figures 17a; 19; 59e; 60m-o; 61k; 62c.

Scopiastes laticeps Scudder, 1963:382 (part, *nec* Breddin).

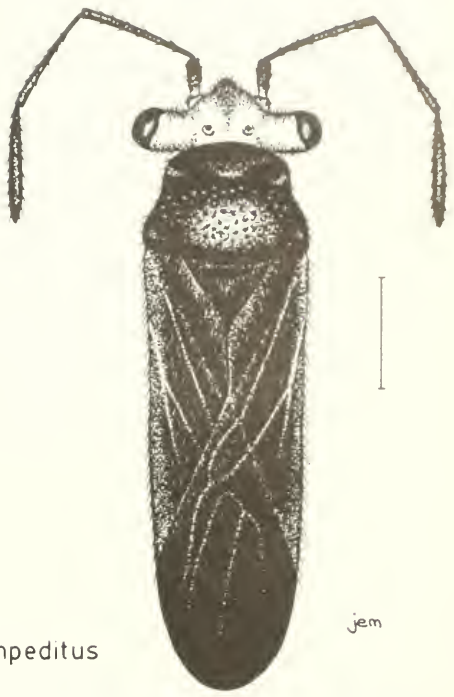


Fig. 19. *Scopiastes impeditus*, sp. nov., dorsal view Scale = 1 mm.

Scopiastes turneri Scudder, 1963:393-394 (part, *nec* Distant).

Types.—Holotype ♀, "Queensland, Imbil State Forest, 5-XI-1957, T. E. Woodward" in QM. Paratypes: 4♂, 3♀, Same data as holotype, in UQ. Also: New South Wales—1♀, Gosford, 22.x.1904, W.B.F.; 2♂, 1♀, Tweed River, 20.x.1901, W.W.F. (NSWDA); 1♀, Ulong, East Dorrigo, W. Heron (AM); 1♀, Rivertree, ii.1930, E. Sutton (DPI); 1♂, Dorrigo National Park via Dorrigo, 9-10.iv.1966, T. Weir (UQ); Queensland—1♀, Binna Burra, 13. xi.1943, A. Blombery; 1♂, 3♀, Bunya Mountains, 2000', 22.i.1938, N. Geary (AM); 2♂, 1♀, Bunya Mountains, 10.xii.1925, H. Hacker; 1♂, National Park, 3000', iii.1929, A. J. Turner; 2♂, Tambourine Mountain, 29.xi.1925, H. Hacker (QM); 1♂, 1♀, Fletcher, iii.1932, E.

Sutton; 1♀, Killarney Plateau, 4.xi. 1932, H. Hacker; 1♂, Tambourine, W.A.T.S. (DPI); 1♂, 1♀, Bunya Mountains, 14.xii.1937, F. A. Perkins; 1♂, 1♀, Fletcher, 28.iii.1929, E. Sutton; 1♂, Joalah National Park, 15.ii.1960, P. R. Webb; 2♀, Lever's Plateau, 12.iii.1966, B. A. Frangmann; 3♂, Lower Ballunjui Falls and Track, Lamington National Park, 30.x.1955, T. E. Woodward; 3♂, 2♀, Tamborine Mountain, 16.ii.1960, F. A. Perkins (UQ).

Description.—Color: The following reddish orange: head except sometimes broad median vitta; clavus usually at least basally along margin of claval suture; corium usually at least basally along costal margin; abdominal segments II to VII except moderately broad, sometimes interrupted longitudinal vitta on each side of venter; coxae; trochanters; pro- and mesofemora ventrally except at apex; and metafemora basally. The following brown to black: broad vitta from front of eye stalk to apex of anteclypeus; pronotum; scutellum; clavus variably; corium variably; thoracic sterna except posterior margins; thoracic pleura except acetabulae; apex of ostiolar peritreme; lateral longitudinal vitta of abdominal venter; genital segments; eye; antenna; labium; pro- and mesofemora dorsally and apically; metafemur except base; tibiae; and tarsi. Antennal segment IV and areas of pro- and mesofemora often lightest. Posterior margins of thoracic sterna, acetabulae and base of ostiolar peritreme pale yellow. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: Short, moderately slender. Clothed with mixture of short, decumbent and longer, upright hairs. Head moderately declivent; anteclypeal bump only slightly produced; ocellus very slightly farther from eye than from other ocellus. Antennal segment I surpassing anteclypeus by about ⅔ its length. Labial segment I reaching or slightly surpassing anterior prosternal margin, II almost reaching posterior margin of procoxa, III reaching about anterior ⅓ of mesosternum, IV reaching about middle of mesocoxa. Pronotum with posterior lobe moderately coarsely, moderately densely punctate. Scutellum with crossbar of T-shaped carina higher and thicker than upright; lateral fovea well developed, coarsely punctate. Hemelytral membrane reaching or slightly surpassing tip of abdomen. Prosternum sparsely, finely, distinctly punctate. Thoracic pleura finely, densely, distinctly punctate. Pygophore convex posteriorly; apex as in Fig. 59e; median projection low, not expanded dorsally. Clasper as in Figs. 60m-o; caudolateral lobe curved strongly dorsad; overhanging lateral projection slightly produced. Ovipositor similar to *S. laticeps* (Figs. 62n, o); apex of second valvula as in Fig. 62c, rather strongly produced, curved mesad apically, venter moderately curved mesad subapically. Spermatheca as in Fig. 61k; sperm pump short, curved.

Measurements: Length ♂ 5.3 (5.0-5.5), ♀ 6.0 (5.6-6.3); abdominal width ♂ 1.6 (1.5-1.6), ♀ 1.8 (1.7-1.8); head length ♂ .52 (.48-.55), ♀ .59 (.51-.69); width across eyes ♂ 1.83 (1.75-1.90), ♀ 1.98 (1.90-2.05); pronotal length ♂ 1.04 (.99-1.09), ♀ 1.12 (1.10-1.19); pronotal width ♂ 1.65 (1.58-1.75), ♀ 1.88 (1.75-2.05); scutellar length ♂ .72 (.59-.78), ♀ .82 (.74-.90); scutellar width ♂ .91 (.85-.98), ♀ 1.03 (.95-1.15); length antennal segments I ♂ .38 (.35-.41), ♀ .40 (.37-.42), II ♂ .98 (.94-1.02), ♀ 1.01 (.97-1.09), III ♂ .93 (.88-.99), ♀ .96 (.92-1.02), IV ♂ 1.07

(1.01-1.12), ♀ 1.10 (1.02-1.14); length labial segments I ♂ .52 (.48-.59), ♀ .59 (.54-.62), II ♂ .48 (.45-.51), ♀ .55 (.50-.58), III ♂ .30 (.29-.32), ♀ .30 (.30-.31), IV ♂ .42 (.40-.45), ♀ .45 (.42-.49).

Measurements holotype ♂. Length 5.2; abdominal width 1.5; head length .48; width across eyes 1.75; pronotal length 1.02; pronotal width 1.64; scutellar length .78; scutellar width .89; length antennal segments I .36, II 1.00, III .94, IV 1.11; length labial segments I .51, II .48, III .29, IV .40.

Comments.—The name *impeditus* is derived from the Latin *impedire* which is what this species did to progress on this revision.

Scopiastes impeditus is very similar to *S. laticeps* in both color and structure. Specimens with completely brown hemelytra are very similar to specimens of *S. turneri* with which it forms a north-south species pair. In addition to the characters in the key, which are consistent and will separate most specimens easily, it differs from *S. laticeps* in that the dark markings are generally lighter and more extensive (all *laticeps* examined had at least some reddish orange on clavus and corium), it appears relatively broader and less attenuate posteriorly, and the pilosity is slightly denser. If in doubt of an identification one should refer to the genitalia, particularly the claspers.

That *S. impeditus* often resembles the sympatric *S. laticeps* more closely in coloration than it does the more closely related *S. turneri* suggests the possibility of Mullerian mimicry. Field studies would be necessary to explore this possibility.

The specimens listed as *S. turneri* from Imbil, Queensland, by Scudder (1963) and those from the following localities listed by Scudder (1963) as *S. laticeps* belong to this species: 1♂, Goodna; 2♂, Tamborine Mt.; 1♂, 2♀, Bunya Mts.; 1♂, Queensland National Park; and 1♂, 1♀, Bunya Mts. The last two specimens in UQ, the rest in QM.

Scopiastes kurandensis, *sp. nov.*

Figures 16b; 17b; 59h; 61a-c; 62j.

Types.—Holotype ♂, "Queensland, Kuranda, 1-IV-1952, C. Oke" in NMV. Paratypes: 1♂, 1♀, same data as holotype, in NMV.

Description.—Color: The following bright orangey red: head except gular area and buccula; extreme apex of clavus; about apical ½ of corium except narrow apical margin; abdomen laterally and medially at base; ocellus; antennal segment I; femora; and tibiae except extreme apices. The following dark brown to black: broad gular area; buccula; pronotum; scutellum; clavus except extreme apex; about basal ½ and narrow apical margin of corium; thoracic sterna; thoracic pleura; abdominal venter except medially and laterally at base; and labium apically. The following brown: eye; labium basally; coxae; trochanters; extreme apices of tibiae; and tarsi. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: As in *S. hackeri* except: apex of pygophore as in Fig. 59h, median projection convex dorsally; clasper (Figs. 61a-c) with caudolateral lobe thick, blunt, overhanging lateral projection directed more anterad; apex of second valvula as in Fig. 62j, not produced ventrally.

Measurements: Holotype ♂. Length 5.9; abdominal width 2.0; head length .63; width across eyes 2.06; pronotal length 1.23; pronotal width 2.00; scutellar length .85; scutellar width .94; length antennal segment I .45; length labial segment I .58.

Measurements of paratype ♂ and ♀.

Length ♂ 6.1, ♀ 6.0; abdominal width ♂ 2.1, ♀ 2.2; head length ♂ .70, ♀ .53; width across eyes ♂ 2.11, ♀ 2.06; pronotal length ♂ 1.25, ♀ 1.11; pronotal width ♂ 2.00, ♀ 2.06; scutellar length ♂ .88, ♀ .89; scutellar width ♂ 1.06, ♀ .98; length labial segments I ♂ .61, ♀ .58, II ♀ .55, III ♀ .33, IV ♀ .45.

Comments.—*Scopiastes kurandensis* is named for the type locality. This species is very similar in appearance to *S. hackeri*. The red coloration is more orange than in *hackeri* and the coloration of the profemora, mesofemora, and the abdominal venter is different. Both male and female genitalia of the two species are quite distinctive.

The type series represents the only known specimens. The first segment of the right antenna of the holotype is all that remains of the antennae.

Scopiastes laticeps *(Breddin 1900)*

Figures 20; 58i-k; 59a; 60a-c; 62a, n, o.

Astacops (Scopiastes) laticeps Breddin, 1900:170-171.

Scopiastes laticeps Scudder, 1963:382; Slater, 1964*a*:190.

Type.—Lectotype ♂, "New South Wales" in Berlin.

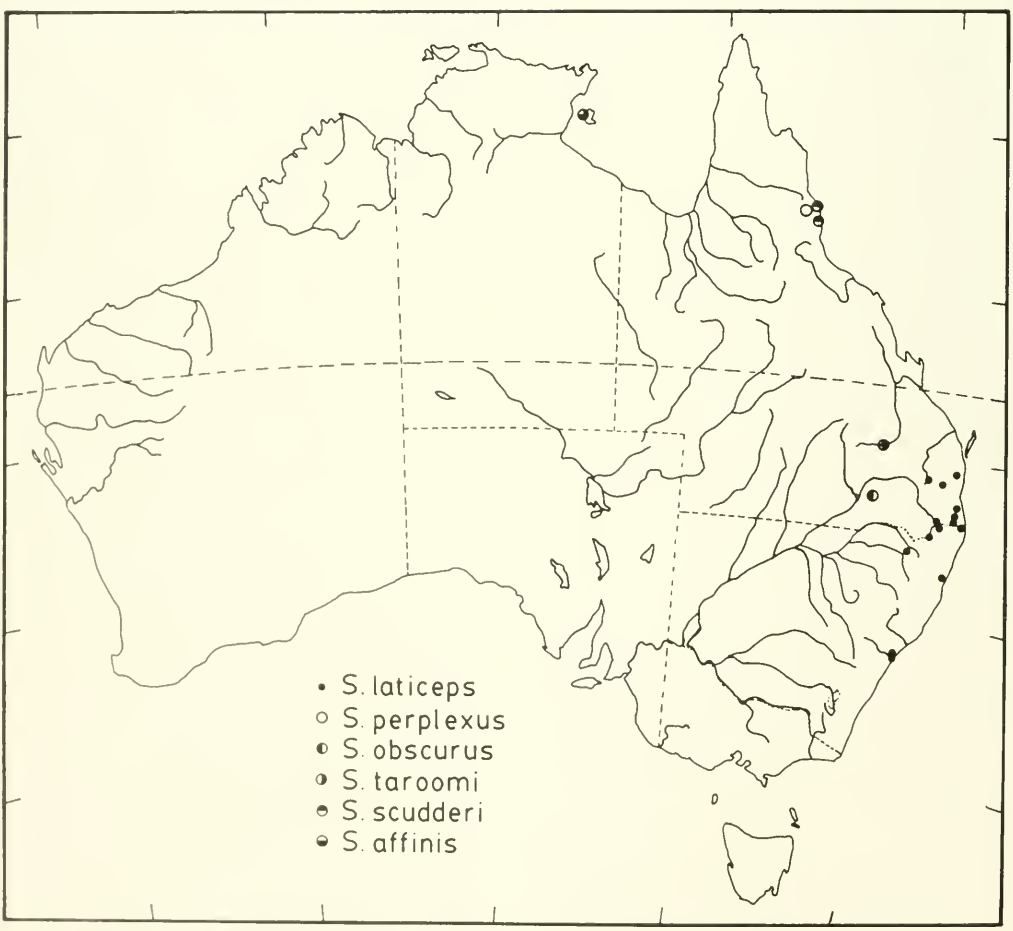


FIG. 20. Distribution of *Scopiastes laticeps* Breddin, *S. perplexus*, sp. nov., *S. obscurus*, sp. nov., *S. taroomi*, sp. nov., *S. scudderi*, sp. nov., and *S. affinis* Distant.

Redescription.—Color: The following reddish orange: head except sometimes dorsal vitta; clavus at least basally along claval suture; corium at least basally along costal margin; abdomen except longitudinal lateral vittae and genital segments; coxae; trochanters; pro- and mesofemora ventrally except apices; and metafemur. The following brown to black: broad vitta from front of eye stalk to apex of anteclypeus; pronotum; scutellum; clavus to varying degree, never along base of claval suture; corium to varying degree, never basally along costal margin; thoracic sterna except posterior margins; thoracic pleura except acetabulae; apex of ostiolar peritreme; longitudinal vitta laterally on abdominal venter; genital segments; eye; antenna; labium; pro- and mesofemora dorsally and apically; metafemur except base; tibiae; and tarsi. Antennal segment IV and pro- and mesofemora often lighter. Posterior margins of thoracic sterna, acetabulae, and base of ostiolar peritreme pale yellow. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: Narrow. Clothed with interspersed short, semidecumbent and longer, upright hairs. Head moderately strongly declivent; anteclypeal bump moderately produced; ocelli slightly farther from eyes than from each other. Antennal segment I surpassing anteclypeus by about ½ its length. Labial segment I slightly surpassing anterior prosternal margin, II almost reaching posterior margin of procoxa, III reaching about middle of mesosternum, IV reaching about middle of mesocoxa. Pronotum with moderately coarsely, moderately densely punctate posterior lobe. Scutellum with upright of T-shaped carina lower than crossbar; lateral fovea narrow, deeply punctate. Prosternum indistinctly punctate. Thoracic pleura finely, very distinctly punctate. Pygophore slightly concave posteriorly; apex as in Fig. 59a; median projection high, narrow, widened dorsally. Clasper as in Figs. 60a-c; caudolateral lobe curved strongly mediodorsad; overhanging lateral projection projecting farther at anterior than at posterior end, slightly bifid, swollen subapically dorsally. Aedeagus similar to *S. degeeri* (Fig. 58f); phallothecal process as in Fig. 58k; ejaculatory reservoir as in Figs. 58i, j. Ovipositor as in Figs. 62n, o; apex of second valvula as in Fig. 62a, strongly curved mesad apically, ventral margin curved strongly mesad subapically. Spermatheca as in Fig. 61j; sperm pump long, tubular, unpigmented.

Measurements: Length ♂ 6.1 (5.6-6.5), ♀ 6.7 (6.5-6.9); abdominal width ♂ 1.6 (1.5-1.7), ♀ 1.9 (1.8-2.0); head length ♂ .54 (.40-.59), ♀ .62 (.50-.85); width across eyes ♂ 1.98 (1.86-2.03), ♀ 2.15 (2.01-2.24); pronotal length ♂ 1.11 (.98-1.18), ♀ 1.21 (1.13-1.28); pronotal width ♂ 1.77 (1.61-1.88), ♀ 2.00 (1.91-2.09); scutellar length ♂ .82 (.71-.89), ♀ .89 (.83-.98); scutellar width ♂ .97 (.86-1.08), ♀ 1.13 (1.06-1.20); length antennal segments I ♂ .41 (.38-.44), ♀ .42 (.38-.44), II ♂ 1.21 (1.15-1.28), ♀ 1.20 (1.15-1.25), III ♂ 1.10 (1.01-1.22), ♀ 1.15 (1.11-1.18), IV ♂ 1.10 (1.07-1.20), ♀ 1.10 (1.05-1.15); length labial segments I ♂ .59 (.56-.65), ♀ .64 (.61-.68), II ♂ .55 (.50-.63), ♀ .61 (.58-.63), III ♂ .35 (.29-.38), ♀ .38 (.36-.40), IV ♂ .50 (.45-.56), ♀ .53 (.50-.55).

Comments.—*Scopiastes laticeps* shows great variability in the extent of the dark hemelytral markings. Most specimens examined have the inner half of the clavus and the outer half of the corium red. Some specimens have no dark areas at all on the hemelytron and

some have the entire hemelytron, except the base along the claval suture and costal margin, dark. The light areas of the venter are usually more orange than those of the dorsum.

This species is similar to *S. impeditus, S. obscurus, S. perplexus,* and *S. taroomi* in general appearance. Dark specimens are somewhat similar to *S. turneri.* Some individuals have hemelytral markings similar to those of *S. degeeri.* The characters given in the key will serve to distinguish most specimens. In doubtful cases one must resort to the clasper, especially the projecting lateral overhang. This is quite distinct from all other species except *S. obscurus* where the shape of the caudolateral lobe is markedly different.

Scopiastes laticeps is apparently restricted to rainforest areas of southeastern Queensland and northern New South Wales. It forms a north-south species pair with *S. perplexus.* Some of the specimens listed as members of this species by Scudder (1963) are referable to *S. impeditus* (which see) and I believe that the specimens he lists from northern Queensland will prove to belong to *S. perplexus.*

Scopiastes melampus *Bergroth 1918*

Scopiastes nigriceps Distant, 1901*a*:533 (preoccupied).

Astacops melampus Bergroth, 1918:57 (new name for *S. nigripes* Distant).

Scopiastes melampus Scudder, 1963:386-387; Slater, 1964*a*:190.

Type.—Type ♀. "Gayndah, Queensland" in BMNH.

Redescription.—Color: The following scarlet: head; anterior pronotal lobe; clavus except extreme base and narrow scutellar margin; corium except extreme base and narrow apical margin; about anterior ⅔ of prosternum; propleuron anteriorly and medially; abdominal sterna II to VI except longitudinal vitta on each side; ocellus; and extreme base of antennal segment I. The following dark brown to black: posterior pronotal lobe; scutellum; extreme base and narrow scutellar margin of clavus; extreme base and narrow apical margin of corium; thoracic sterna except prosternum anteriorly; propleuron posteriorly; propleural acetabula; meso- and metapleura; longitudinal vitta on each side of abdominal venter, broader and darker posteriorly, nearly meeting medially on sternum VI; sternum VII; and genital segments. Eye, antenna except extreme base of segment I, labium, and legs dark brown suffused with red. Hemelytral membrane subhyaline, dark brown basally becoming paler apically.

Structure: Moderately robust. Head moderately strongly declivent; anteclypeal bump strongly produced; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by about ½ its length. Labial segment I slightly surpassing anterior prosternal margin, II almost reaching posterior margin of procoxa, III almost reaching middle of mesosternum, IV reaching posterior margin of mesocoxa. Pronotum with extremely coarsely, densely punctate posterior lobe. Hemelytral membrane moderately surpassing tip of abdomen.

Measurements: Holotype ♀. Length 8.5; width across eyes 2.33; pronotal length 1.59; pronotal width 2.42; length antennal segments I .42, II 1.09, III .92.

Comments.—I have not seen this species. The description is based on excellent color slides of the dorsum and venter kindly supplied by Mr. W. D. Dolling of the British Museum (Natural History). The measurements are from Scudder (1963).

Scopiastes melampus is a very distinc-

tive species. It is somewhat similar to *S. degeeri* but lacks the triangular macula at the apical corial margin and the partially red legs of that species. The dorsal coloration is similar to that of *S. affinis* which lacks the lateral vittae of the abdominal venter.

Scopiastes obliquus *Scudder 1963*

Figures 17a; 21; 59i, m-o; 61n; 62l.

Scopiastes obliquus Scudder, 1963:389.

Types.—Holotype ♀, "Gayndah, Queensland, A. M. Lea" in SAM. Paratypes: 1♀, same data as holotype, in ANIC; 2♀, 1♂, "Eidsvold, Queensland, 6-X-1929, M. J. Mackerras"; 1♂, "Eidsvold, Queensland, 6-X-1929"; 1♀, "Wallaville, Queensland, T. L. Bancroft" all in ANIC.

Redescription.—Color: Head except median vitta, base of clavus, and corium except irregular, oblique, median fascia reddish orange. The following orange: anterior pronotal lobe; humerus, sometimes lateral margin, sometimes posterior margin of posterior pronotal lobe; scutellum except extreme base; lateral and posterior metapleural margins; abdomen; coxae; trochanters; and ovate longitudinal medial macula ventrally on each femur. The following dark brown to black: broad longitudinal vitta from level of ocellus to apex of anteclypeus; posterior pronotal lobe except humerus and sometimes posterior and lateral margins; extreme base of scutellum; clavus except base; oblique irregular corial fascia; thoracic sterna except anterior and posterior prosternal margins; thoracic pleura except acetabulae, posterior mesopleural margin, and lateral and posterior metapleural margins; apex of ostiolar peritreme; eye; antenna; labium; femora except ventral maculae; tibiae; and tarsi. The following pale yellowish orange: anterior and posterior prosternal margins; acetabulae; posterior mesopleural margin; lateral and posterior metapleural margins; and base of ostiolar peritreme. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

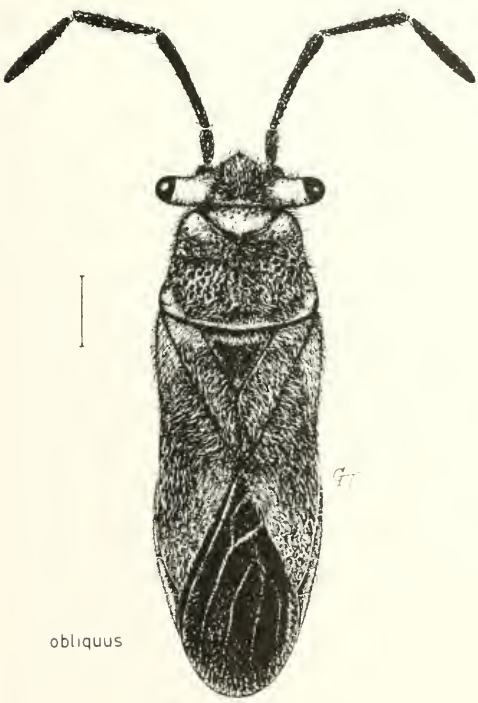


FIG. 21. *Scopiastes obliquus* Scudder, dorsal view. Scale = 1 mm.

Structure: Robust. Clothed with interspersed short, decumbent and long, upright hairs. Head very strongly declivent; anteclypeal bump moderately produced; ocelli nearly twice as far from eyes as from each other. Antennal segment I surpassing anteclypeus by slightly more than ½ its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching posterior procoxal margin; III slightly surpassing center of mesosternum, IV reaching about posterior margin of mesocoxa. Pronotum with densely, very coarsely punctate posterior lobe.

Scutellum with low, broad T-shaped median carina, crossbar slightly higher than upright; lateral fovea reduced, appearing as group of interconnected very coarse, deep punctures. Hemelytral membrane moderately surpassing tip of abdomen. Thoracic pleura indistinctly punctate except coarsely, shallowly punctate slightly behind middle; posterolateral metapleural angle produced slightly posteriorly. Pygophore truncate posteriorly; apex as in Fig. 59i; median projection blunt apically. Clasper as in Figs. 59m-o; robust; caudolateral lobe elongate, curving dorsad; lateral excavation with sinuate ridges; lateral projection scarcely excavated, dorsal ridge concave. Aedeagus similar to *S. degeeri* (Fig. 58f), phallotheca very heavily pigmented. Ovipositor similar to *S. laticeps* (Figs. 62n, o); apex of second valvula as in Fig. 62l, slightly produced, convex ventrally. Spermatheca as in Fig. 61n; robust; sperm pump ovate, heavily pigmented basally.

Measurements: 4♂, 8♀. Length ♂ 8.0 (7.9-8.4), ♀ 8.4 (7.7-9.0); abdominal width ♂ 2.4 (2.3-2.5), ♀ 2.5 (2.2-2.8); head length ♂ .68 (.64-.81), ♀ .66 (.53-.75); width across eyes ♂ 2.50 (2.48-2.56), ♀ 2.61 (2.45-2.68); pronotal length ♂ 1.49 (1.48-1.51), ♀ 1.52 (1.42-1.60); pronotal width ♂ 2.40 (2.31-2.52), ♀ 2.57 (2.31-2.78); scutellar length ♂ 1.10 (1.05-1.15), ♀ 1.25 (1.05-1.36); scutellar width ♂ 1.29 (1.25-1.34), ♀ 1.46 (1.25-1.58); length antennal segments I ♂ .54 (.53-.56), ♀ .54 (.48-.60), II ♂ 1.53 (1.47-1.58), ♀ 1.44 (1.35-1.49), III ♂ 1.32 (1.25-1.41), ♀ 1.31 (1.29-1.34), IV ♂ 1.38, ♀ 1.40 (1.31-1.51); length labial segments I ♂ .73 (.72-.75), ♀ .83 (.80-.86), II ♂ .71 (.70-.74), ♀ .75 (.71-.81), III ♂ .52 (.50-.55), ♀ .56 (.54-.60), IV ♂ .68 (.66-.70), ♀ .71 (.68-.74).

Comments.—The combination of oblique corial fascia and unicolored venter separate *S. obliquus* from all other Australian *Scopiastes*. The spermatheca and clasper are very distinctive, showing little similarity to any of the other species. The slightly projecting posterolateral metapleural angle is unique to this species within the genus. The range appears to be restricted to southern Queensland.

Scopiastes obscurus, *sp. nov.*

Figures 20; 59d; 60d-f.

Type.—Holotype ♂, "Queensland, 69km. E. of St. George, 20-XII-1976, E. M. Exley and T. Low, on *Angophora floribunda*" in QM.

Description.—Color: The following yellowish orange: head except longitudinal median vitta; clavus along base of claval suture; about basal half of costal corial margin; abdominal segments II to VII except genital segments and moderately broad longitudinal vitta on each side; coxae; trochanters; pro- and mesofemora except dorsoapically; and about basal half of metafemur. The following dark brown to black with purplish cast: broad vitta from ocellus to apex of anteclypeus; pronotum; scutellum; thoracic sterna and pleura; longitudinal lateral vitta on each side of abdominal venter; genital segments; antennal segments I to III; apical half of metafemur; tibiae; tarsomere III of pro- and mesotarsi; and metatarsus. The following brown: clavus except basally along claval suture; corium except basal half of costal margin; eye; antennal segment IV; labium; pro- and mesofemora dorsoapically; and tarsomeres I and II of pro- and mesotarsi. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: Moderately slender. Clothed with interspersed short, semi-

decumbent and long, upright hairs, the latter very long except on hemelytra. Head moderately strongly declivent; anteclypeal bump moderately produced; ocelli slightly closer to eyes than to each other. Antennal segment I surpassing anteclypeus by slightly more than ½ its length. Labial segment I slightly surpassing anterior prosternal margin, II surpassing about anterior ⅔ of procoxa, III surpassing about anterior ⅓ of mesosternum, IV reaching mesocoxa. Pronotum with moderately densely, moderately coarsely punctate posterior lobe. Scutellum with upright of T-shaped carina slender, slightly lower than crossbar; lateral fovea narrow, moderately coarsely punctate. Hemelytral membrane slightly surpassing tip of abdomen. Prosternum indistinctly punctate. Thoracic pleura finely, distinctly punctate. Pygophore nearly truncate posteriorly; apex as in Fig. 59d; median projection widened dorsally only at apex. Clasper as in Figs. 60d-f; caudolateral lobe directed caudad; lateral overhang projecting equally far anteriorly and posteriorly. Aedeagus similar to *S. degeeri* (Fig. 58f).

Measurements: Holotype ♂. Length 5.7; abdominal width 1.7; head length .50; width across eyes 1.94; pronotal length 1.05; pronotal width 1.74; scutellar length .81; scutellar width .98; length antennal segments I .41, II 1.10, III 1.01, IV .98; length labial segments I .59, II .50, III .28, IV .43.

Comments.—*Scopiastes obscurus'* name refers to the difficulty in distinguishing it from *S. laticeps*. It is very similar to *laticeps* in color and structure. *Scopiastes obscurus* is slightly less elongate, the light color is yellowish orange rather than reddish orange, and antennal segments II, III, and IV are relatively slightly shorter than in *laticeps*. The claspers are also very similar but differ as mentioned in the key. *Scopiastes obscurus* appears slightly fuzzier than *S. laticeps*, perhaps due to slightly longer upright hairs on the head and body, excluding the hemelytra. From the type locality it appears to be adapted to drier conditions than are most species in the genus. The holotype male is the only known specimen.

Scopiastes perplexus, *sp. nov.*

Figures 20; 59b; 60g-i; 62b.

Types.—Holotype ♂, "Queensland, Atherton, 23-V-1917, A. Sewadeni" in QM. Paratypes: 2♀, same data as holotype, in QM; 5♂, 4♀, same data as holotype, in DPI.

Description.—Color: Pattern as in dark specimens of *S. laticeps*. Dark areas brown, light areas reddish orange.

Structure: Narrow, elongate. Clothed with interspersed short, decumbent and long, upright hairs. Head moderately strongly declivent; anteclypeal bump moderately produced; ocelli slightly farther from eyes than from each other. Antennal segment I surpassing anteclypeus by about half its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching posterior margin of procoxa, III surpassing anterior third of mesosternum, IV reaching middle of mesocoxa. Pronotum with moderately coarsely, moderately densely punctate posterior lobe. Scutellum with low T-shaped carina, equally high throughout; lateral fovea well developed, moderately coarsely and deeply punctate. Prosternum indistinctly punctate. Thoracic pleura finely, indistinctly punctate, more coarsely and distinctly on metapleuron. Pygophore slightly concave posteriorly; apex as in Fig. 59b; median projection low, widened dorsally, bluntly rounded apically. Clasper as in Figs. 60j-l; caudolateral lobe directed more posteriorly than dorsally;

lateral excavation very deep; lateral overhang with ventral ridge. Ovipositor similar to *S. laticeps* (Figs. 62n, o); apex of second valvula as in Fig. 62b, very strongly produced, strongly twisted apically. Spermatheca similar to *S. laticeps* (Fig. 61j).

Measurements: 6♂, 6♀. Length ♂ 5.7 (5.5-5.9), ♀ 6.2 (5.9-6.6); abdominal width ♂ 1.6 (1.5-1.7), ♀ 1.8 (1.7-2.0); head length ♂ .52 (.48-.61), ♀ .51 (.45-.54); width across eyes ♂ 1.94 (1.88-1.99), ♀ 2.09 (2.00-2.23); pronotal length ♂ 1.04 (1.00-1.10), ♀ 1.13 (1.10-1.21); pronotal width ♂ 1.72 (1.63-1.78), ♀ 1.95 (1.80-2.11); scutellar length ♂ .79 (.74-.83), ♀ .87 (.82-.98); scutellar width ♂ .95 (.90-.98), ♀ 1.11 (1.03-1.22); length antennal segments I ♂ .40 (.39-.43), ♀ .42 (.40-.45), II ♂ 1.14 (1.09-1.20), ♀ 1.15 (1.10-1.24), III ♂ 1.07 (1.00-1.13), ♀ 1.08 (1.00-1.18), IV ♂ 1.11 (1.10-1.12), ♀ 1.09; length labial segments I ♂ .58 (.55-.63), ♀ .63 (.61-.65), II ♂ .56 (.50-.60), ♀ .60 (.58-.63), III ♂ .34 (.31-.38), ♀ .37 (.36-.38), IV ♂ .48 (.45-.50), ♀ .54 (.53-.56).

Measurements holotype ♂. Length 5.8; abdominal width 1.6; head length .55; width across eyes 1.88; pronotal length 1.00; pronotal width 1.71; scutellar length .79; scutellar width .90; length antennal segments I .39, II 1.15, III 1.13, IV 1.10; length labial segments I .63, II .60, III .38, IV .50.

Comments.—The name of *Scopiastes perplexus* derives from my difficulty in differentiating it from related species. It is very similar to *S. laticeps* in both color pattern and structure. The two species form a north-south species pair. They may be separated by the characters given in the key and by the very different male and female genitalia.

Scopiastes perplexus is known only from the type series. This series was recorded by the collector as "playing havoc among potato plants."

Scopiastes scudderi, *sp. nov.*

Figures 20; 22; 59h; 60s-u; 62e.

Types.—Holotype ♂, "Queensland, Upper Mulgrave River, 30-IV-1970, G. B. Monteith" in QM. Paratypes: 2♂, 3♀, same data as holotype, in UQ; 1♀, "Eubangee, Queensland, VIII-1949, J. G. Brooks" in AM.

Description.—Color: The following yellow, sometimes suffused with orange: head; abdomen except longitudinal vitta laterally on abdominal venter; basal half of antennal segment I; labial segment I; coxae; trochanters; pro- and mesofemora; and basal half of metafemur. The following dark brown to black, faintly suffused with red: pro-

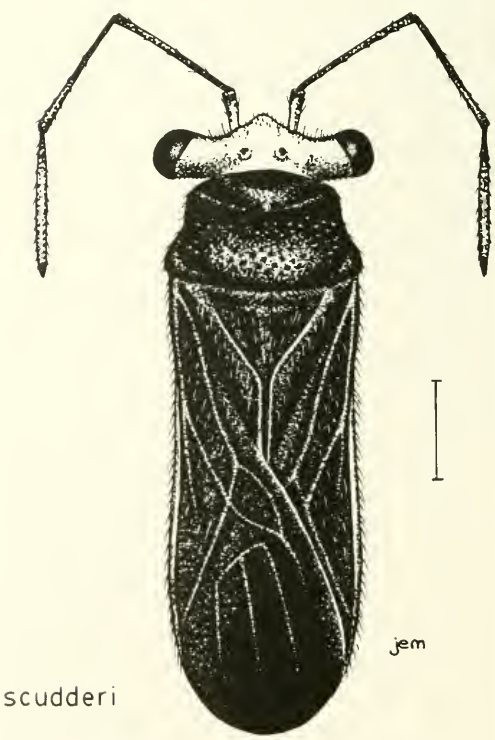


FIG. 22. *Scopiastes scudderi*, sp. nov., dorsal view. Scale = 1 mm.

notum; scutellum; clavus; corium; thoracic sterna; thoracic pleura except acetabulae and base of ostiolar peritreme; longitudinal, lateral vitta uninterrupted on abdominal sterna II to IV, narrowed, interrupted, and paler on sterna V and VI; and eye. Antenna except basal half of segment I, labial segments II to IV, apical half of metafemur, tibiae, and tarsi brown. Abdominal sternum VII medially, genital segments, and occasionally head dorsomedially lightly infuscated. Ocellus red. Hemelytral membrane subhyaline, dark brown basally becoming nearly clear apically.

Structure: Rather delicate in appearance. Clothed with interspersed short, semidecumbent and long, upright hairs. Head moderately strongly declivent; anteclypeal bump strongly produced; ocelli about 1½ times as far from eyes as from each other. Antennal segment I surpassing anteclypeus by slightly more than half its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching posterior coxal margin, III surpassing anterior ⅔ of mesosternum, IV reaching middle of mesocoxa. Pronotum with lateral margin of anterior lobe finely granulate, appearing dull; posterior lobe moderately coarsely, very densely punctate. Scutellum with well developed median T-shaped carina, crossbar higher, slightly thicker than upright; lateral fovea narrow, deeply punctate. Prosternum indistinctly punctate. Thoracic pleura moderately punctate. Pygophore nearly truncate posteriorly; apex as in Fig. 59h; median projection convex dorsally, truncate apically. Clasper as in Figs. 60s-u; caudolateral lobe short, strongly curved dorsad; lateral excavation shallow, a dorsoventral ridge from apex of overhang to base. Aedeagus similar to *S. degeeri* (Fig. 58f). Ovipositor with apex of second valvula as in Fig. 62e, flat, moderately produced, slightly curving mesad. Spermatheca similar to *S. bicolor* (Fig. 61l).

Measurements: 3♂, 4♀. Length ♂ 5.7 (5.5-5.9), ♀ 6.3 (6.1-6.5); abdominal width ♂ 1.6 (1.6-1.6), ♀ 1.9 (1.8-1.9); head length ♂ .54 (.48-.59), ♀ .67 (.58-.74); width across eyes ♂ 1.94 (1.90-1.99), ♀ 2.10 (2.04-2.13); pronotal length ♂ 1.04 (.98-1.09), ♀ 1.15 (1.08-1.23); pronotal width ♂ 1.74 (1.71-1.75), ♀ 1.94 (1.88-2.01); scutellar length ♂ .78 (.78-.78), ♀ .87 (.83-.93); scutellar width ♂ .91 (.88-.94), ♀ 1.05 (1.03-1.08); length antennal segments I ♂ .44 (.43-.45), ♀ .47 (.46-.48), II ♂ 1.32 (1.29-1.35), ♀ 1.36 (1.35-1.36), III ♂ 1.28 (1.28-1.29), ♀ 1.29 (1.29-1.30), IV ♂ 1.37 (1.36-1.38), ♀ 1.38 (1.35-1.40); length labial segments I ♂ .60 (.60-.60), ♀ .67 (.64-.70), II ♂ .55 (.54-.55), ♀ .61 (.60-.61), III ♂ .34 (.34-.35), ♀ .39 (.38-.40), IV ♂ .48 (.46-.51), ♀ .54 (.53-.54).

Measurements holotype ♂. Length 5.6; abdominal width 1.6; head length .48; width across eyes 1.99; pronotal length .98; pronotal width 1.75; scutellar length .78; scutellar width .94; length antennal segment I .44, II 1.35, III 1.29, IV 1.38; length labial segments I .60, II .55, III .34, IV .51.

Comments.—*Scopiastes scudderi* is named for Dr. G. G. E. Scudder. The species is similar to *S. turneri* in general appearance but the appendages appear more slender, the light areas are more yellow than orange, and the dark dorsal markings are darker than in that species. It is apparently restricted to northern Queensland (Fig. 20).

Scopiastes taroomi, *sp. nov.*

Figures 20; 59g; 60v, w, x.

Type.—Holotype ♂, "Queensland, Taroom, XII-1930" in QM.

Description.—Color: The following orange, palest on abdomen: head except anteclypeus; clavus; corium; abdomen except broad longitudinal vitta laterally on venter, sternum VII medially, and genital segments; ocellus; coxae; trochanters; pro- and mesofemora; and basal 1/4 of metafemur. The following dark brown to black: eye; pronotum; scutellum; thoracic sterna and pleura except acetabular margins; genital segments; apical 3/4 of metafemur; and metatibia. Anteclypeus, antenna, labium, pro- and mesotibiae, and tarsi brown, antennal segment IV lightest. The following infuscated: clavus apically; corium except costal margin; and pro- and mesofemora apically. Hemelytral membrane dark brown basally becoming lighter apically.

Structure: Rather narrow and elongate. Clothed with interspersed short, decumbent and long, upright hairs. Short hairs absent on granulate, dull areas. Head moderately strongly declivent; anteclypeal bump moderately developed; ocelli about 1 1/2 times as far from eyes as from each other. Antennal segment I surpassing anteclypeus by about 2/3 its length. Labial segment I reaching anterior prosternal margin, II surpassing about anterior third of procoxa, III slightly surpassing procoxa, IV reaching mesocoxa. Pronotum with anterior lobe and anterior margin of posterior lobe finely granulate, appearing dull; posterior lobe very densely, very deeply punctate. Hemelytral membrane slightly surpassing tip of abdomen. Prosternum moderately punctate. Thoracic pleura somewhat coarsely punctate. Pygophore convex posteriorly; apex as in Fig. 59g; median projection short, blunt apically. Clasper as in Figs. 60v-x; caudolateral lobe short, subconical, curving dorsad; deeply excavated laterally with greatly produced projecting overhang. Aedeagus similar to *S. degeeri* (Fig. 58f).

Measurements. Holotype ♂. Length 6.4; abdominal width 1.9; head length .61; width across eyes 2.28; pronotal length 1.18; pronotal width 1.94; scutellar length .93; scutellar width 1.08; length antennal segments I .48, II 1.19, III 1.12, IV 1.30; length labial segments I .60, II .53, III .36, IV .46.

Comments.—*Scopiastes taroomi* is named for the type, and only known, locality. The species is similar to *S. laticeps* and *S. perplexus* in size and coloration. It is easily separated from both by the granulate anterior pronotal lobe. From the type locality it appears that *S. taroomi* is adapted to drier conditions than the majority of the genus.

Scopiastes turneri *Distant 1918*

Figures 17a; 62d.

Scopiastes turneri Distant, 1918:416; Scudder, 1963:393-394 (part); Slater, 1964*a*:191.

Type.—Type ♀, "Kuranda, N. Queensland, 366 m, 21-VI/24-VII-1913, R. E. Turner" in BMNH.

Redescription.—Color: The following orange, darkest on head: head except apex of anteclypeus; abdominal sterna II to VI except longitudinal vitta on each side; abdominal sternum VII laterally; coxae; trochanters; meso- and metafemora except apically; and basal third of metafemur. The following dark brown to black: apex of anteclypeus; pronotum; scutellum; clavus; corium except base of costal margin; thoracic sterna; thoracic pleura except acetabulae; apex of ostiolar peritreme; abdominal sternum VII medially; lateral longitudinal vitta on abdominal sterna II to VI; and genital segments. The following brown: eye; costal corial margin basally; antennal segments II

to IV, sometimes I; labium; apices of pro- and mesofemora; apical 2/3 of metafemur; tibiae; and tarsi. Acetabulae, base of ostiolar peritreme, and sometimes antennal segment I pale orangey yellow. Hemelytral membrane subhyaline, dark brown basally becoming lighter apically.

Structure: Small, slender. Clothed with interspersed short, decumbent and long, upright hairs. Head strongly declivent; anteclypeal bump moderately strongly produced; ocelli slightly closer to each other than to eyes. Antennal segment I surpassing anteclypeus by about 2/3 its length. Labial segment I slightly surpassing anterior prosternal margin, II reaching middle of procoxa, III surpassing about anterior 1/4 of mesosternum, IV reaching middle of mesocoxa. Pronotum with narrow lateral margin of anterior lobe finely granulate, appearing dull; posterior lobe moderately coarsely, very densely punctate. Scutellum with moderately developed T-shaped carina, crossbar much higher than upright; lateral fovea small, moderately coarsely punctate. Hemelytral membrane slightly surpassing tip of abdomen. Prosternum shallowly, distinctly punctate. Thoracic pleura shallowly, moderately coarsely punctate, more strongly on propleuron. Ovipositor similar to *S. laticeps* (Fig. 62n, o); apex of second valvula as in Fig. 62d, flattish, apical projection short, curving somewhat mesad. Spermatheca similar to *S. impeditus* (Fig. 61k).

Measurements: 2♀. Length 5.5, 5.6; abdominal width 1.6, 1.7; head length .43, .50; width across eyes 1.93, 2.03; pronotal length .98, 1.04; pronotal width 1.70, 1.80; scutellar length .74, .81; scutellar width .91, .99; length antennal segments I .41, .43, II 1.15, 1.15, III 1.08, 1.13, IV 1.25, 1.30; length labial segments I .54, .58, II .53, .53, III .30, .34, IV .46, .46.

Comments.—*Scopiastes turneri* is very similar to *S. scudderi* and to dark specimens of *S. impeditus*, forming a north-south species pair with the latter. It differs from *scudderi* in size (smaller), in the lateral abdominal vittae being uninterrupted and about equally broad throughout, and in antennal segment IV being slightly longer in comparison to segment II. *Scopiastes impeditus* usually has at least the base of the costal corial margin orange, is slightly larger, and has all antennal segments shorter than those of *turneri*. The structure of the apex of the second valvula is distinctive for all three species.

I have not seen males of this species. The specimens from Imbil State Forest, Queensland, mentioned by Scudder (1963) belong to *S. impeditus*. The species appears to be restricted in its range (Fig. 17a).

Scopiastes yorkensis, *sp. nov.*

Figures 17b; 59c; 60j-l; 62h.

Types.—Holotype ♂, "Queensland, Dividing Range, 15 km W. of Captain Billy Creek, Cape York Peninsula, 4/9-VII-1975, G. B. Monteith" in QM. Paratype ♀, "Queensland, Dividing Range, 15 km W. of Captain Billy Creek, Cape York Peninsula, 142°45′ E, 11°40′ S, 4/9-VII-1975, G. B. Monteith" in UQ.

Description.—Color: The following yellow suffused with orange: head except longitudinal dorsal vitta; anterior pronotal lobe; scutellum; thoracic sterna except mesosternum laterally; thoracic pleura except acetabulae and posterior margins; and abdominal segments II to VII except interrupted lateral vitta. The following dark brown

to black: broad dorsal vitta from ocellus to apex of anteclypeus; clavus; corium; apex of ostiolar peritreme; evaporative area; subquadrate macula laterally on abdominal sterna III to VII, not reaching posterior margins, forming interrupted vitta; genital segments; eye; antenna; labium; and legs. Mesosternum infuscated laterally. Posterior pronotal lobe brown, darker at humerus. Acetabulae and posterior margins of thoracic pleura pale yellow. Ocellus orange. Hemelytral membrane subhyaline, dark brown basally becoming nearly clear apically.

Structure: Very similar to *S. bicolor* except: long upright hairs of dorsum longer, sparser; apex of second valvula as in Fig. 62h; apex of pygophore as in Fig. 59c, median projection higher, slightly thickened dorsally; and clasper as in Figs. 60j-l, caudolateral lobe bent dorsad, lateral overhang more produced, dorsal ridge lower.

Measurements: Holotype ♂, paratype ♀. Length ♂ 6.9, ♀ 8.1; abdominal width ♂ 2.0, ♀ 2.3; head length ♂ .64, ♀ .75; width across eyes ♂ 2.48, ♀ 2.70; pronotal length ♂ 1.31, ♀ 1.54; pronotal width ♂ 2.13, ♀ 2.55; scutellar length ♂ .93, ♀ 1.06; scutellar width ♂ 1.13, ♀ 1.30; length antennal segments I ♂ .52, ♀ .54, II ♂ 1.48, ♀ 1.62, III ♂ 1.33, ♀ 1.54, IV ♂ 1.65, ♀ 1.86; length labial segments I ♂ .60, ♀ .68, II ♂ .55, ♀ .60, III ♂ .40, ♀ .48, IV ♂ .60, ♀ .64.

Comments.—*Scopiastes yorkensis* is named for the type locality. It may be separated from the very similar *S. bicolor* by the characters given in the key, the generally lighter dorsum, and the genitalia. The species is known only from the type series.

Thunbergia Horváth

Caenocoris s.g. *Thunbergia* Horváth, 1914:633; Slater, 1964*a*:44.

Thunbergia Slater, 1978:854.

Type-species *Alydus marginatus* Thunberg 1822, monobasic.

Diagnosis.—Antennal segment IV much longer than II; head swollen behind eye; forefemur of both sexes with short stout subapical spine; anterior pronotal margin raised, forming distinct collar; meso- and metapleura impunctate or nearly so; aedeagus with conjunctiva greatly produced laterally, two lightly pigmented, laterally directed, pointed lobes and a lightly pigmented basally directed lobe on either side, and two very small, basally directed, pigmented projections dorsally; and valvulae of ovipositor much reduced, scarcely laciniate.

Thunbergia and *Achrobrachys* were erected by Horváth (1914) as subgenera of *Caenocoris* Fieber. Horváth provided a key to subgenera but placed only the type species to subgenus. Slater (1978) raised both of Horváth's subgenera to generic level and gave generic placements for most species previously contained in *Caenocoris*. The three genera *Achrobrachys, Caenocoris,* and *Thunbergia* are remarkable among the Lygaeinae in having the valvulae of the ovipositor reduced and scarcely laciniate. The conjunctiva of the aedeagus is partially sclerotized and at least moderately expanded laterally. In *Achrobrachys* and *Thunbergia* the conjunctiva is quite similar to that of some coreids and rhopalids. It seems likely that during copulation this expansion allows a firm union of the male and female genitalia in the absence of the long bearing surface normally provided by the laciniate ovipositor.

The majority of *Thunbergia* species occur on islands between Asia and Australia. The generic range is from India in the west, the Philippines in the east and the Queensland-New South

Wales border in Australia in the south. Most but not all species are associated with rainforest.

Redescription.—Color: Red or orange dorsally. Hemelytral membrane and scutellum mostly black. Thoracic venter mostly black. Abdominal venter red or orange with black transverse vittae. The following often pruinose and so appearing lighter than their surroundings: thoracic venter except posterior pleural margins; gular area; and base of scutellum.

Structure: Large, elongate. The following finely granulate appearing dull: thorax; scutellum; clavus; corium; base of head dorsally; and gular area. Abdomen, remainder of head, antenna, labium, and legs shining. Body densely covered with moderately to very long hairs, these shortest on base of pronotum and on hemelytra, finest on thoracic pleura, semidecumbent on abdominal venter. Dense fringe of short posteriorly directed hairs on posterior pronotal margin. Head scarcely declivent, convex; buccula moderately prominent and curved mesad anteriorly, very low posteriorly, ventral margin nearly straight, almost reaching anterior prosternal margin; eye considerably removed from anterolateral pronotal angle; head behind eye moderately swollen; ocelli much closer to eyes than to each other. Antennal segment I scarcely surpassing anteclypeus; IV considerably longest, blunt apically; I and IV slightly thicker than II and III. Labium surpassing metacoxa; segment I slightly thicker than II; II slightly thicker than III and IV; IV slightly swollen subapically. Pronotum convex; much narrower anteriorly than posteriorly; coarsely deeply punctate behind callus except at posterior margin; median carina faintly indicated; anterior margin concave, swollen, forming distinct collar; posterior margin straight to slightly concave medially, produced slightly to rear laterad of scutellum; lateral margin convex anteriorly, concave medially, convex towards humerus; slightly but distinctly explanate at least anteriorly; callus moderately swollen, separated from anterior margin by very short depressed punctate area, nearly at level of hemelytra dorsally; callar impression oblique, sinuate, unbranched; posterior lobe much higher posteriorly than anteriorly, separated from callus by interrupted deeply punctate impression, a nearly transverse impression at posterior margin near humerus. Scutellum blunt apically; upright of T-shaped carina slightly swollen apically, strongly swollen basally, crossbar very strongly swollen; lateral fovea in angle of T deep basally scarcely indicated apically, coarsely and deeply punctate. Hemelytron with costal margin nearly straight, slightly constricted opposite claval commissure; veins slightly prominent; membrane surpassing tip of abdomen. Prosternum with anterior margin raised, a few coarse punctures immediately behind anterior margin. Meso- and metasterna impunctate, swollen, longitudinally sulcate medially. Propleuron coarsely punctate anteriorly and posteriorly, impunctate centrally; anterior margin raised. Mesopleuron impunctate; a deep posterolateral pit almost connected to lateral (dorsal) margin by a faintly defined curved impression perhaps analogous to the anterolateral gland openings of abdominal sterna of other lygaeines. Metapleuron impunctate; posterior margin truncate to slightly convex, directed dorsoventrally; ostiolar peritreme well developed. Femora scarcely swollen; forefemur of both sexes with short stout subapical spine. Abdominal sternum II almost completely visible laterally; VI as long me-

dially as laterally; male VII concave posteriorly; female VII cleft to base, membranous medially, posterior margin concave laterally; sterna without dorsolateral gland openings. Abdominal dorsum with fused para- and mediotergites; outer and inner laterotergites distinct except fused together and with median tergites on segment VII; posterior margin of median tergite I concave, of II and III moderately convex, of IV produced posteriorly at middle, of VI truncate, of VII concave; tergum VII laterally rounded and produced posterad. Pygophore broadly, shallowly excavated dorsally; posterior margin produced broadly posterad; median projection well developed, low; a lateral projection of lateral margin of dorsal opening just anterior to insertion of clasper. Clasper without caudolateral lobe; blade curved, twisted, subcircular in cross section basally, becoming flatter apically; shank variously excavated anterolaterally. Aedeagus with moderately sclerotized phallotheca; phallothecal process scarcely produced, C-shaped ridge dorsally; conjunctiva large, robust, cylindrical at base, greatly expanded with four pigmented acute projections on each side; low lobe over ejaculatory reservoir; ejaculatory reservoir complete, with broad Y-shaped basal projection; vesica basally thin, twisted; ring sclerite at most indicated by light sclerotization; vesica apically coiled and fused, forming pigmented cup; gonoporal process long, coiled, without visible surrounding membrane, contained in vesical cup when retracted. Ovipositor with very reduced valvulae, rami very short; connecting membrane of first valve lightly pigmented, cleft to about ⅓ distance from base of first valvula; second valvulae broadly separated, connected only at base. Spermatheca with pigmented apical bulb surmounting circular flange; sperm pump immediately basal to flange, unsclerotized, narrowing gradually to long thin unsclerotized basal tube.

Key to the Australian Species of Thunbergia

1. Posterior pronotal margin produced posteriorly into a short triangular "flap" on each side of scutellum; pronotum bright red with no black markings. . . . . *augur* (Stål)
1′. Posterior pronotal margin scarcely produced on either side of scutellum (appearing slightly convex laterally, slightly concave medially); pronotum orange or purplish-red, usually with black marking anteriorly 2
2. Pronotum greatly swollen dorsally at humeral angles. . . . . *tumidus,* sp. nov.
2′. Pronotum not swollen dorsally at humeral angles, posterior lobe evenly convex 3
3. Dark purplish-red above; abdomen greenish yellow. . . . . *torrida* (Distant)
3′. Dorsum and abdomen orange . . 4
4. Femora concolorous with tibiae and tarsi; labium reaching or almost reaching abdominal sternum V. . . . . *marcida,* sp. nov.
4′. Femora red, tibiae and tarsi black; labium almost reaching abdominal sternum IV. . . . . *rufifemur,* sp. nov.

Thunbergia augur *Stål 1865*

Figures 23; 63a, d, g, j, k; 64c; 65b, d-f; 66a, b.

Lygaeus augur Stål, 1865:187.
Caenocoris augur Stål, 1874:116; Slater, 1964*a*:40.
Thunbergia augur Slater, 1978:854, 855.

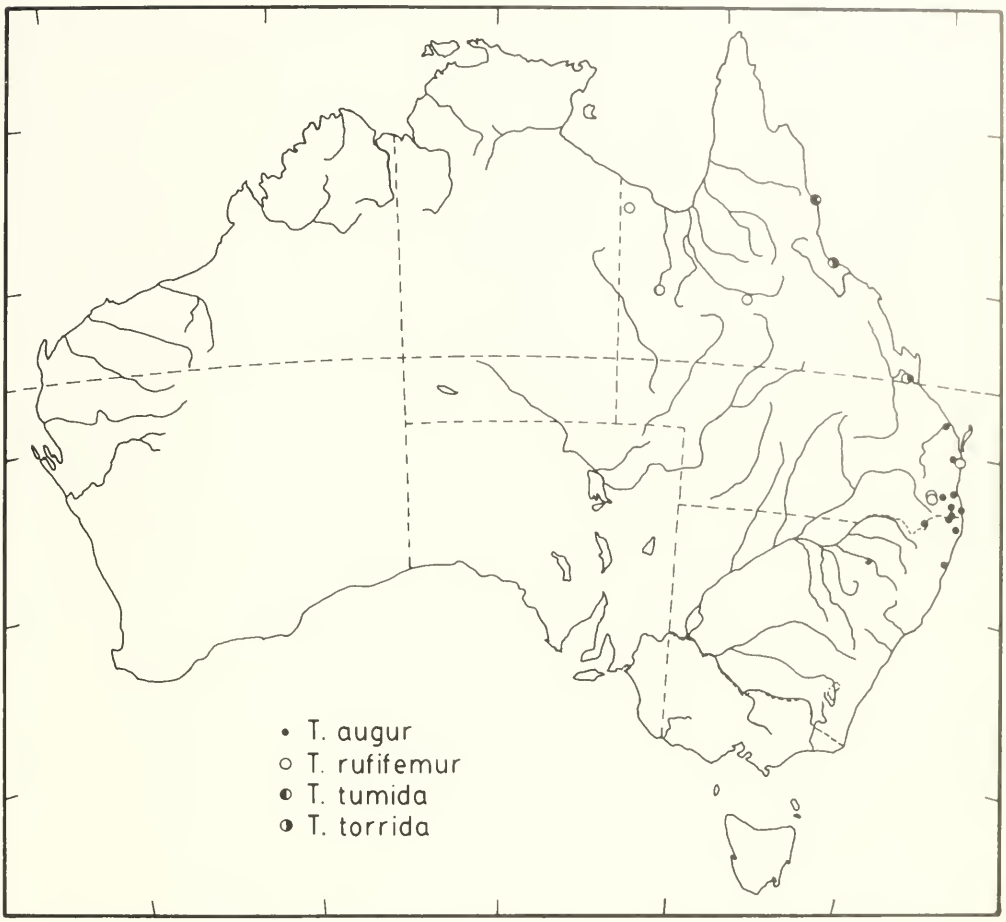


FIG. 23. Distribution of *Thunbergia augur* (Stål), *T. rufifemur*, sp. nov., *T. tumida*, sp. nov., and *T. torrida* (Distant).

Types.—Lectotype ♀, "Moreton Bay." "Stevens." in Stockholm. Paralectotype ♀, same data as lectotype, in Stockholm.

Redescription.—Color: Bright blood red. The following deep black: basal 2/3 of scutellum; thoracic sterna; thoracic pleura except lateral margins; a transverse vitta on each side of abdominal sterna III to VI, not reaching lateral margin, usually narrowly connected medially on III to V, covering posterior 2/3 of each sternum except narrow posterior margin, reduced on VI; antenna; labium; and legs. Eye brown. Ocellus red. Hemelytral membrane black with blue-green irredescence basally; small whitish mark at basal angle; shading from dark brown through subhyaline brown to hyaline apically. Hairs dorsally dark brown to black; ventrally whitish except brown to black on and around transverse abdominal vittae; brown to black on legs, lighter on tarsal pads and antennal segment IV.

Structure: Callus separated from pronotal collar by single row of punctures; punctures on posterior pronotal lobe often coalescent; pronotal emargination only slightly developed; posterior pronotal lobe evenly convex;

posteriorly directed projection of posterior pronotal margin well developed; transverse impression near posterior pronotal margin just anterior to posterior projection; labial segment I slightly surpassing anterior prosternal margin, II almost reaching mesocoxa, III at least reaching center of abdominal sternum III, IV at least reaching center of abdominal sternum IV. Pygophore as in Figs. 63a, d. Clasper as in Figs. 65d-f. Aedeagus as in Figs. 63g, 64c, d; ejaculatory reservoir as in Figs. 63j, k. Ovipositor as in Figs. 66a, b. Spermatheca as in Fig. 65b.

Measurements: Length ♂ 15.2 (13.8-16.2), ♀ 18.0 (17.0-19.3); abdominal width ♂ 4.2 (3.5-4.5), ♀ 5.1 (4.7-5.4); head length ♂ 1.64 (1.44-1.88), ♀ 1.82 (1.64-2.06); width across eyes ♂ 2.23 (1.94-2.40), ♀ 2.43 (2.30-2.54); pronotal length ♂ 2.20 (1.84-2.40), ♀ 2.59 (2.30-2.92); pronotal width ♂ 3.87 (3.41-4.22), ♀ 4.68 (4.38-4.97); scutellar length ♂ 2.12 (1.96-2.36), ♀ 2.57 (2.36-2.76); scutellar width ♂ 2.32 (2.20-2.52), ♀ 2.81 (2.60-3.00); length antennal segments I ♂ .75 (.64-.82), ♀ .83 (.78-.88), II ♂ 2.88 (2.54-3.22), ♀ 3.23 (2.98-3.40), III ♂ 2.61 (2.25-2.97), ♀ 2.98 (2.79-3.20), IV ♂ 4.06 (3.64-4.39), ♂ 4.43 (4.28-4.73); length labial segments I ♂ 2.05 (1.88-2.24), ♀ 2.33 (2.24-2.40), II ♂ 2.55 (2.10-3.28), ♀ 2.92 (2.76-3.06), III ♂ 3.23 (2.96-4.04), ♀ 3.57 (3.32-3.80), IV ♂ 1.90 (1.70-2.28), ♀ 2.00 (1.86-2.16).

Comments.—The bright blood red coloration and the development of the posterior pronotal projections separate this species from others in Australia. These two characters together with the red head, completely black first antennal segment, and lack of a tooth on each posterior pronotal projection separate it from all members of the genus known to me.

Thunbergia augur is restricted to the eastern coastal region of Australia, penetrating as far south as northern New South Wales (Fig. 23). It is associated with rainforest. Specimens have been collected on *Parsonsia straminia* and *Araujia hortorum*.

Thunbergia marcida, *sp. nov.*

Type.—Holotype ♂, "Cape York, Queensland." in SAM.

Description.—Color: Pale orange, clavus and corium darker. The following infuscated: anterior half of pronotum except collar; basal ⅔ of scutellum; gular area; posterior half of prosternum; mesosternum medially; metasternum; center of propleuron; meso- and metapleura except lateral, posterior and ventral margins, and ostiolar peritreme; abdominal sternum II except middle and lateral margin; and a transverse macula on abdominal sterna III to VII posteriorly, not reaching lateral margin, reduced on VII. Labium and legs light orangey brown becoming darker apically. Eye brown. Ocellus red. Hemelytral membrane with white basal angle, otherwise brown basally shading to whitish hyaline apically. Dark markings pruinose.

Structure: Hairs short. Callus separated from pronotal collar by two rows of fine punctures; punctures of posterior pronotal lobe shallow, coarse; lateral pronotal margin slightly explanate; posterior pronotal margin scarcely produced posteriorly lateral to scutellum, slightly convex laterally, slightly concave medially; crossbar of T-shaped scutellar carina only moderately swollen; scutellum acute apically; propleuron narrowly impunctate centrally; labial segment I slightly surpassing anterior prosternal margin, II about reaching mesocoxa, III about reaching posterior margin of abdomi-

nal sternum III, IV about reaching posterior margin of abdominal sternum V; abdominal sterna III and IV distinctly sulcate medially; abdominal sternum V faintly sulcate medially at anterior margin.

Measurements: Holotype ♂. Length 10.5; abdominal width 2.6; head length 1.54; width across eyes 1.88; pronotal length 1.68; pronotal width 2.72; scutellar length 1.52; scutellar width 1.68; antenna missing; labial segments I 1.48, II 1.72, III 2.42, IV 1.36.

Comments.—The type male of *Thunbergia marcida* is the only specimen known to me. Both antennae, the left fore tarsus, both mid tarsi, the left hind leg and the pygophore are missing. The specimen appears somewhat teneral and I believe that the infuscated areas would be black in a fully mature specimen. The general body color might also become darker orange.

The small size and long labium separate this species from other members of the genus.

Thunbergia rufifemur, *sp. nov.*

Figures 23; 24; 63c, f, h, l, m; 64b, h-j; 65c; 66c, d.

Types.—Holotype ♂, "Queensland, Richmond, VIII-1965, A. Fenwick" in QM. Paratypes: 2♂, 1♀, same data as holotype, in UQ; 1♀, "Allora, Queensland, 29-1-1951, J. Letchford"; 1♀, "Caloundra, Queensland, 4-I-1958, L. Clark"; 1♂, "Queensland, Knob Lagoon, 3 miles N.W. of Doomadgee Mission, 22-V-1972, G. B. & S. R. Monteith"; 1♀, "Queensland, Lake Mondarra, 12 miles from Mt. Isa, 3-XI-1967, E. M. Exley, on *Eucalyptus* sp."; 1♂, "Toowoomba, 2-VI-1937, N. T. M. Yeats" all in UQ; 1♀, "Rockhampton" in AM; 1?, "Peak-Downs" and 1♂, "Sidney" in BMNH.

Description.—Color: Pale orange. The following black: callus; base of scutellum except lateral margin; prosternum except narrow anterior margin; meso- and metasterna medially; propleuron except narrow anterior, lateral, and acetabular margins; mesopleuron except narrow lateral and acetabular margins; metapleuron

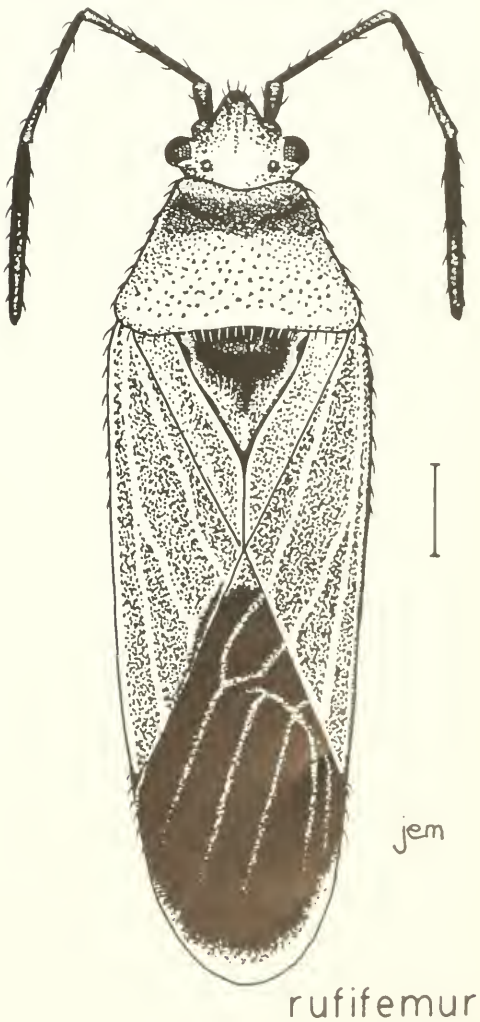


FIG. 24. *Thunbergia rufifemur*, sp. nov., dorsal view. Scale = 1 mm.

except narrow lateral, posterior, and acetabular margins and ostiolar peritreme; and a transversely ovate macula on each side of abdominal sterna III to VI. The following orangey red: head; basal 2/3 of antennal segment I, at least ventrally; labial segment I dorsally; and ostiolar peritreme. The following purplish-brown: antennal segment I apically antennal segments II to IV; tibiae; tarsi; and sometimes apices of femora. Coxae, trochanters, and femora except sometimes apices red. Abdomen pale orange basally gradually deepening in color to become orangey red at apex. Hairs pale. Hemelytral membrane with white basal angle, otherwise dark brown with bluish irridescence basally becoming hyaline at apex.

Structure: Hairs fairly short; callus separated from pronotal collar by double row of punctures laterally, single row medially; few small punctures medially on callus; pronotum only slightly explanate laterally; posterior pronotal margin scarcely produced posteriorly, convex laterally, concave medially; T-shaped scutellar carina with crossbar only moderately swollen; only very center of propleuron impunctate; labial segment I reaching anterior prosternal margin, II reaching middle of mesosternum, III reaching posterior margin of metacoxa, IV reaching abdominal sternum IV. Pygophore as in Figs. 63e, f. Clasper as in Figs. 64h-j. Aedeagus similar to *T. augur* (Figs. 64c, d); phallothecal process as in Figs. 63h, 64b; ejaculatory reservoir as in Figs. 63l, m. Ovipositor as in Figs. 66c, d. Spermatheca as in Fig. 65c.

Measurements: 4 ♂, 7 ♀. Length ♂ 10.9 (10.6-11.3), ♀ 12.6 (12.3-13.5); abdominal width ♂ 3.2 (3.1-3.3), ♀ 3.6 (3.2-3.9); head length ♂ 1.22 (1.18-1.30), ♀ 1.48 (1.36-1.60); width across eyes ♂ 1.88 (1.88-1.90), ♀ 2.04 (1.92-2.14); pronotal length ♂ 1.76 (1.72-1.82), ♀ 2.03 (1.78-2.20); pronotal width ♂ 3.21 (3.10-3.38), ♀ 3.70 (3.28-3.92); scutellar length ♂ 1.66 (1.60-1.72), ♀ 1.89 (1.64-2.14); scutellar width ♂ 1.77 (1.70-1.86), ♀ 2.06 (1.72-2.20); length antennal segment I ♂ .57 (.53-.62), ♀ .61 (.55-.68), II ♂ 1.94 (1.90-1.99), ♀ 2.08 (1.93-2.27), III ♂ 1.84 (1.76-1.90), ♀ 1.97 (1.81-2.18), IV ♂ 2.48 (2.37-2.56), ♀ 2.48 (2.08-2.77); length labial segments I ♂ 1.34 (1.30-1.36), ♀ 1.45 (1.32-1.46), II ♂ 1.62 (1.52-1.72), ♀ 1.79 (1.56-1.92), III ♂ 2.02 (1.92-2.12), ♀ 2.22 (2.08-2.40), IV ♂ 1.37 (1.32-1.40), ♀ 1.40 (1.28-1.48).

Measurements holotype ♂. Length 10.6; abdominal width 3.1; head length 1.22; width across eyes 1.88; pronotal length 1.72; pronotal width 3.10; scutellar length 1.60; scutellar width 1.70; length antennal segments I .55, II 1.90, III 1.80, IV 2.37; length labial segments I 1.36, II 1.60, III 2.00, IV 1.40.

Comments.—*Thunbergia rufifemur* is named for the distinctively colored femora. The species is easily recognized by the pale orange dorsum, orangey red head, and bright red femora. A single female lacks the black callar marking and the black marking of the scutellum except two small basal spots. The dark markings on the thoracic venter of that specimen are represented by infuscated areas.

The few specimens in collections indicate that the range is broad within Queensland, possibly extending into New South Wales (Fig. 23). It is apparently an inhabitant of drier areas than the other Australian members of the genus.

Thunbergia torrida *Distant 1918*

Figures 23; 63b, e, i, n, o; 64a, e-g; 65g; 66e, f.

Caenocoris torridus Distant, 1918: 176-177; Slater, 1964*a*:44.
Thunbergia torrida Slater, 1978:854, 857.

Types.—Lectotype ♀, "Townsville, Qld., F. P. Dodd." "Queensland. F. P. Dodd 1904-284." in BMNH. Paralectotypes: 1♂, same data as lectotype, in BMNH; 1♀, "Cooktown, Philip de la Garde, 1906-89; 2♂, 3♀, "Queensland, F. P. Dodd, 1904-284" all in BMNH.

Redescription.—Color: Dark purplish-red. The following black: anterior ½ pronotum except very narrow anterior margin; scutellum except apex; broad gular area; prosternum except narrow anterior and coxal margins; meso- and metasterna medially; propleuron except narrow anterior margin and produced posterolateral angle; meso- and metapleura except dorsal, posterior, and acetabular margins and ostiolar peritreme; and transverse fascia not reaching lateral margin near posterior margins of abdominal sterna III to VI. Abdomen except black fasciae greenish yellow, suffused with orange dorsally. Antenna, labium, femora, tibiae, and tarsi dark purplish-brown. Eye brown. Ocellus red. Hemelytral membrane with white basal angle, otherwise black with bronzy irridescence basally becoming pale hyaline apically. Hairs pale yellow.

Structure: Hairs fairly short; callus separated from pronotal collar by irregular row of punctures; pronotum scarcely impressed behind callus, slightly explanate; callus sparsely punctate; posterior pronotal margin scarcely produced posteriorly lateral of scutellum, convex laterally, concave medially; T-shaped scutellar carina with crossbar moderately swollen; propleuron completely punctate; labial segment I reaching anterior prosternal margin, II reaching about anterior ⅓ of mesosternum, III reaching about middle of mesocoxa, IV almost reaching posterior margin of abdominal sternum III. Pygophore as in Figs. 63b, c. Clasper as in Figs. 64e-g. Aedeagus similar to *T. augur* (Figs. 64d, c); phallotheca as in Figs. 63i, 64a; ejaculatory reservoir as in Figs. 63n, o. Ovipositor as in Figs. 66e, f. Spermatheca as in Fig. 65g.

Measurements: 4♂, 5♀. Length ♂ 11.5 (10.8-12.0), ♀ 13.9 (12.7-15.3); abdominal width ♂ 3.0 (2.8-3.3), ♀ 3.9 (3.5-4.3); head length ♂ 1.32 (1.20-1.44), ♀ 1.52 (1.34-1.68); width across eyes ♂ 1.88 (1.78-1.94), ♀ 2.08 (1.96-2.22); pronotal length ♂ 1.78 (1.60-1.88), ♀ 2.10 (1.74-2.48); pronotal width ♂ 3.02 (2.80-3.16), ♀ 3.72 (3.34-4.12); scutellar length ♂ 1.70 (1.62-1.84), ♀ 2.03 (1.88-2.16); scutellar width ♂ 1.72 (1.58-1.88), ♀ 2.15 (1.92-2.40); length antennal segments I ♂ .58 (.55-.59), ♀ .64 (.58-.69), II ♂ 1.99 (1.92-2.14), ♀ 2.12 (1.96-2.38), III ♂ 1.91 (1.85-2.06), ♀ 2.13 (1.95-2.29), IV ♂ 3.14 (2.90-3.36), ♀ 3.30 (2.85-3.56); length labial segments I ♂ 1.35 (1.32-1.36), ♀ 1.51 (1.44-1.68), II ♂ 1.62 (1.54-1.68), ♀ 1.84 (1.78-1.90), III ♂ 1.98 (1.78-2.20), ♀ 2.26 (2.10-2.42), IV ♂ 1.30 (1.26-1.40), ♀ 1.48 (1.36-1.58).

Comments.—The dark purplish-red dorsal coloration and greenish-yellow abdomen separate *T. torrida* from other Australian members of the genus. It is very similar structurally to *T. rufifemur* and in structure and color to a possibly undescribed species from Timor but differs slightly in antennal and labial segment measurements.

Thunbergia torrida appears to be restricted to northeastern Queensland (Fig. 23). I have seen only one specimen in addition to the type series.

Thunbergia tumida, *sp. nov.*

Figures 23; 65a; 66g, h.

Type.—Holotype ♀, "Kuranda, Queensland, F. P. Dodd" in SAM.

Description.—Color: Orange, clavus and corium darkest. The following infuscated: pronotum medially immediately behind callar area; basal ⅔ of scutellum; apex of clavus; gular area; posterior half of prosternum; mesosternum medially; metasternum; propleuron centrally; mesopleuron posteriorly and on acetabulae; metapleuron anteriorly and on acetabulae; and a medial, transverse fascia, extending about halfway to lateral margin near posterior margins of abdominal sterna III and IV. Abdomen except fasciae orange. Antenna except basal part of segment I, labium, and legs purplish-brown. Eye brown. Ocellus red. Hemelytral membrane with whitish basal angle, otherwise dark brown with greenish irridescence basally becoming pale hyaline apically. Dark markings of body pruinose and so appearing lighter than they would otherwise.

Structure: Ocellar protuberance very well developed; callar area and pronotal collar connected medially by remnant of median pronotal carina; pronotal punctation fine; posterior pronotal lobe with very pronounced slightly transverse swelling at humerus; posterior pronotal margin almost straight; T-shaped scutellar carina with greatly swollen crossbar; hemelytra not completely covering abdomen apically, scarcely reaching apex of abdomen; labial segment I surpassing anterior prosternal margin by about ⅙ its length, II reaching about anterior ⅓ of mesosternum, III reaching about anterior ⅓ of metacoxa, IV reaching about middle of abdominal sternum III; abdominal sternum III distinctly sulcate medially, IV with faint indication of median sulcus. Ovipositor as in Figs. 66g, h. Spermatheca as in Fig. 65a.

Measurements: Holotype ♀. Length 16.0; abdominal width 4.7; head length 1.60; width across eyes 2.62; pronotal length 2.60; pronotal width 4.69; scutellar length 2.60; scutellar width 2.80; length antennal segments I .74, II 2.76, III 2.76, IV missing; length labial segments I 2.04, II 2.20, III 2.70, IV 1.76.

Comments.—The type female, the only specimen known to me, is unfortunately in poor condition. It lacks the right antenna, segment IV of the left antenna, the right fore and hind legs beyond the coxae, the left hind and mid tarsi, and most of the dorsal hairs. It seems likely that the infuscated areas of the dorsum and of the thoracic venter are normally darker and more extensive. In particular the entire anterior half of the pronotum except the collar is probably normally blackish as this area is pruinose and in other species of the genus such pruinosity is confined to dark areas. There is no indication that the specimen is teneral.

Thunbergia tumida and a closely related species from New Guinea are the only members of the genus with pronounced humeral swellings. The New Guinea species is much darker except the legs which are much lighter, especially the coxae and trochanters. It is also somewhat slimmer, more heavily punctate and has a noticeably longer labium.

Woodwardiastes, GEN. NOV.

Type-species *Woodwardiastes exilis,* sp. nov.

Diagnosis.—Eyes stylate; head moderately declivent; buccula angulate anteriorly; antennal segment I very elongate, surpassing anteclypeus by ⅚

its length; metasternum swollen; dorsolateral lobe slightly beyond middle on each side of conjunctiva; ejaculatory reservoir with greatly expanded and flattened Y-shaped basal projection; vesica with lateral projections and hook-shaped pigmented lobe distal of ring sclerite; and spermatheca with elongate apical bulb and with sperm pump indistinctly differentiated from basal tube.

Woodwardiastes is somewhat similar to *Scopiastes* and *Scopiastella* in general appearance. The elongate first antennal segment, angulate bucculae, and the genitalia all serve to separate it from these and other genera with stylate eyes.

Description.—Color: The following dark brown to black: pronotum; hemelytra; thoracic sterna except narrow anterior and posterior prosternal margins; legs beyond trochanters except femora ventrally; antennal segments I to III; and extreme base of antennal segment IV. The following yellow: head; trochanters; apices of coxae; femora ventrally; and antennal segment IV except extreme base. Abdomen bright scarlet.

Structure: Elongate, depressed, nearly parallel-sided, venter finely granulate, dull. Hairs very short, decumbent, a few slightly longer and upright. Head moderately declivent, slightly impressed anterior of ocellus; eye stylate; ocellus small, about level with vertex, as far from eye as from other ocellus; buccula concave, moderately prominent, sharply angulate anteriorly, tapered posteriorly, not reaching prosternum. Antennal segment I surpassing anteclypeus by about 6/7 its length; II longest. Labial segment I thickest, not reaching prosternum; segments II to IV progressively thinner. Pronotum shiny, subquadrate, narrower anteriorly than posteriorly, slightly constricted and impressed behind callus; posterior lobe slightly higher than anterior lobe; anterior margin straight; posterior margin slightly convex; lateral margin slightly sinuate; anterior lobe impunctate; posterior lobe very densely, moderately coarsely punctate; callus slightly swollen; callar impression oblique, slightly sinuate, unbranched, slightly thickened near medial end; a shallow impression at posterior margin lateral of scutellum. Scutellum subacute apically; T-shaped median carina well developed, crossbar strongly swollen; lateral fovea shallow, slightly punctate. Clavus and corium granulate, subshining, not covering outer laterotergites; costal corial margin slightly sinuate. Hemelytral membrane reaching apex of abdomen. Thoracic sterna impunctate; posterior margins raised; metasternum swollen, sometimes strongly. Thoracic pleura finely, shallowly, moderately densely punctate; posterior metapleural margin slightly concave, directed either dorsoventrally or slightly posteroventrally; posterolateral metapleural angle slightly produced; ostiolar peritreme well developed. Abdomen without dorsolateral gland openings; sternum II not covered laterally by metapleuron; female sternum VII cleft to base, slightly concave laterally; male sternum VII slightly concave. Pygophore rotund; median projection well developed, narrow, subacute apically; tergum IX poorly differentiated from membrane of dorsal foramen. Clasper with short caudolateral lobe with acute, sinuate apical process; blade narrow, rounded in cross section, strongly curved, acute apically; shank shallowly excavated, a thin overhanging dorsal projection. Aedeagus with phallotheca strongly sclerotized ventrally, obliquely im-

pressed on either side ventrally near base, a membranous lateral swelling on each side near base; phallothecal process short, convex, dorsally directed; conjunctiva tubular, narrowed apically, a subconical dorsolateral lobe on each side slightly distal of middle, low dorsal lobe over ejaculatory reservoir; ejaculatory reservoir complete, Y-shaped basal projection with arms greatly expanded and flattened; vesica basally robust, subtubular, twisted apically; ring sclerite complete, broad basally, narrowed apically; vesica apically flattened, twisted, expanded into two lateral projections near ring sclerite, pigmented hook-shaped lobe near middle, coiled and tubular near apex, covered visibly by membrane to apex, twisted subapically; secondary gonopore flared, without apical process. Ovipositor with narrow first valvula almost reaching apex of connecting membrane, bent inwards subapically; connecting membrane of first valve notched apically, two distinct submedian sclerites; second valvula thin, widest apically; connecting membrane of second valve strongly pigmented or lightly sclerotized submedially, cleft about half distance to base. Spermatheca short; apical bulb elongate, pigmented; subapical flange pigmented; basal tube and sperm pump unpigmented, indistinctly separated, moderately thick.

Key to the Species of Woodwardiastes

1. Thoracic pleura orange; abdomen without longitudinal vitta on each side . . . . . *exilis,* sp. nov.

1'. Thoracic pleura dark brown to black with narrow pale yellow margins; a broad dark brown to black longitudinal vitta on each side of abdomen *monteithi,* sp. nov.

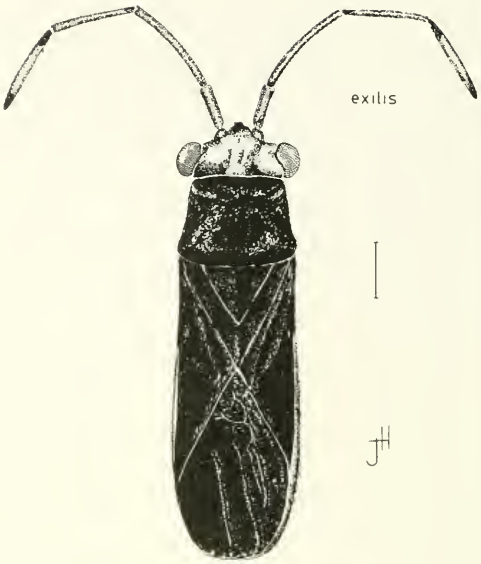


FIG. 25. *Woodwardiastes exilis,* sp. nov., dorsal view. Scale = 1 mm.

Woodwardiastes exilis, *sp. nov.*

Figures 12b; 25; 67a-i.

Type.—Holotype ♂, "Parada, May, 1969, I. E. C., ex light trap." in QM.

Description.—Color: The following yellow: narrow anterior and posterior prosternal margins; narrow posterior and acetabular margins of thoracic pleura; and about basal half of metafemur dorsally. Extreme apex of anteclypeus and eye brown. Thoracic pleura except narrow posterior and acetabular margins but including ostiolar peritreme pale orange. Ocellus reddish orange. The following dark brown to black: abdominal sternum VII except broad lateral margin; genital segments; a small rounded macula on each side of abdominal sterna V and VI.

Structure: Buccula rather broadly angulate anteriorly; only lateral margins of outer laterotergites visible dorsally; metasternum moderately swollen; posterior metapleural margin directed slightly posteroventrally. Scu-

tellum acute apically. Labial segment I extending about ¾ distance to prosternum, II almost reaching procoxa, III almost reaching posterior margin of procoxa; IV reaching middle of mesosternum. Pygophore as in Figs. 67h, j. Clasper as in Figs. 67e-g. Aedeagus as in Figs. 67a, b; ejaculatory reservoir as in Figs. 67c, d.

Measurements: Holotype ♂. Length 7.7; abdominal width 2.1; head length .83; width across eyes 2.34; pronotal length 1.48; pronotal width 2.18; scutellar length 1.04; scutellar width 1.15; length antennal segments I .87, II 2.06, III 1.60, IV 1.86; length labial segments I .63, II .56, III .49, IV .59.

Comments.—*Woodwardiastes exilis* and *M. monteithi* are very similar in general appearance. It is possible that the great disparity in size, distinctive ventral coloration, and structural differences are due to sexual dimorphism. As other genera of Lygaeinae do not show such dimorphism I believe it best to consider them separate species. The name *exilis* refers to the slender general aspect of the species. The holotype male is the only specimen known to me.

Woodwardiastes monteithi, *sp. nov.*

Figures 12b; 68a-d.

Type.—Holotype ♀, "Mount Lewis via Julatten, 3,500', 4-V-1970, G. B. Monteith" in QM.

Description.—Color: The following pale yellow: narrow anterior and posterior prosternal margins; narrow propleural margins; narrow lateral, posterior, and acetabular meso- and metapleural margins; ostiolar peritreme; and extreme base of antennal segment I. The following dark brown to black: propleuron except narrow margins; mesopleuron except narrow lateral, posterior, and acetabular margins; metapleuron except narrow lateral, posterior, and acetabular margins and ostiolar peritreme; abdominal sternum VII except broad lateral margin; genital segments; and a very broad longitudinal vitta on each side of abdominal venter. Trochanters lightly infuscated ventrally.

Structure: Buccula very acutely angulate anteriorly; outer laterotergites almost completely visible; metasternum strongly swollen; posterior metapleural margin directed almost dorsoventrally. Scutellum subacute apically. Labial segment I reaching or almost reaching prosternum, II reaching procoxa, III slightly surpassing procoxa, IV surpassing about anterior ⅔ of mesosternum. Ovipositor as in Figs. 68a, c, d. Spermatheca as in Fig. 68b.

Measurements: Holotype ♀. Length 10.4; abdominal width 3.3; head length .95; width across eyes 2.65; pronotal length 1.94; pronotal width 2.91; scutellar length 1.39; scutellar width 1.60; length antennal segments I 1.04, II 2.40, III 1.92, IV 2.08; length labial segments I .76, II .73, III .63, IV .71.

Comments.—*Woodwardiastes monteithi* is very similar to *W. exilis* in structure and in dorsal coloration. The coloration of the venter is quite distinctive. In addition to the great disparity in size it differs from *exilis* in having the head slightly more declivent, the bucculae more strongly produced and more acutely angulate anteriorly, the first labial segment extending farther posteriorly, and the metasternum more strongly swollen. This species is named for the collector of the type specimen.

Aspilocoryphus Stål

Aspilocoryphus Stål, 1874:117; Slater, 1964*a*:30, 1964*b*:47; Hamid and Meher, 1973*a*:35-36.

Type-species *Lygaeus fasciativentris* Stål, 1858 (fixed by Distant, 1904).

Diagnosis.—Base of head completely black; ostiolar peritreme black; posterolateral angle of metapleuron produced, nearly covering abdominal sternum II; body with short dense decumbent hairs; paratergites separated from mediotergites II to VI; phallotheca with lateral spur.

The genus *Graptostethus,* very similar to *Aspilocoryphus* in general appearance, usually has at least a pale spot at the base of the vertex, has the medio- and paratergites fused, and lacks the phallothecal spur.

Four of the eight species presently assigned to *Aspilocoryphus* occur in the oriental region, three are known only from Africa, and one occurs only in Australia. Due to the external similarity between *Aspilocoryphus* and *Graptostethus,* and the lack of recent work on either genus, there is a good chance that some species are at present incorrectly placed. Slater and Sperry (1973: 131-133) described the nymphs and biology of the African species *A. fasciativentris* (Stål).

The generic descriptions in this paper are based on characteristics held in common by all their Australian members. Since there is only one Australian *Aspilocoryphus* species the species description fulfills that function. I have therefore omitted a generic redescription for this genus.

Aspilocoryphus australicus *Stål 1874*

Figures 26; 27; 69a-l.

Aspilocoryphus australicus Stål, 1874:117; Slater, 1964*a*:30; Slater, 1978:855.

Types.—Lectotype ♀, "Austral. boreal." in Stockholm. Paralectotypes, 2♀, same data as holotype, in Stockholm.

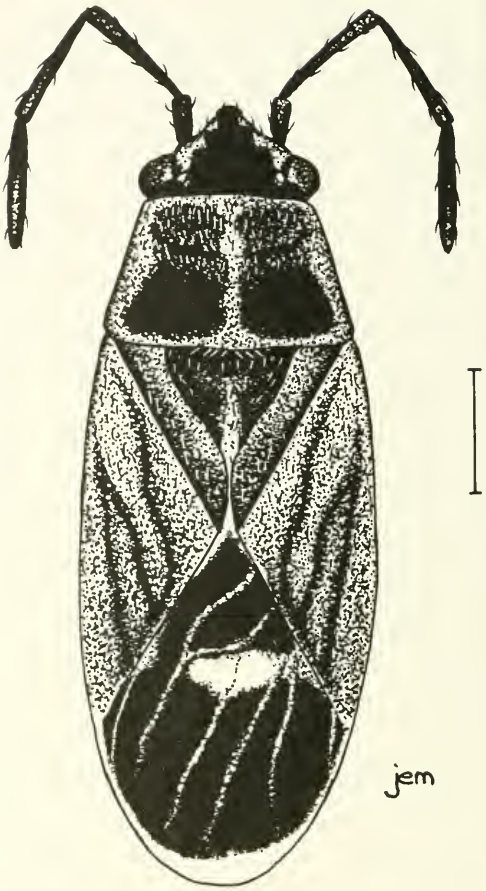


FIG. 26. *Aspilocoryphus australicus* Stål, dorsal view. Scale = 1 mm.

Redescription.—Color: Pinkish orange. The following dark brown to black: head except two narrowly separated dorsolateral maculae on either side extending from laterad of anteclypeus to base of eye between ocellus and antenniferous tubercle; large, rectangular, longitudinal macula on side of pronotum; scutellum except stem of T-shaped median carina and apex; hemelytral membrane except narrow white border becoming wider at apex, and large white discal macula narrowly connected to border; prosternum posteriorly; meso- and metasterna;

propleuron centrally; meso- and metapleura anteriorly including ostiolar peritreme; irregular macula at posterolateral angle of each pleuron; anterolateral angles of abdominal sterna II to VII; narrow posterior border of sterna IV to VI; sternum VII except posterolateral margin; antenna; legs; and labium. Dark dorsal markings of head, base of pronotal macula, scutellar fovea, membrane, and posterolateral propleural macula darker than rest. Clavus and corium lightly infuscated except posterior claval and anterior ⅔ of costal corial margin; veins more heavily infuscated. Buccula pallid. Eye brown. Ocellus red.

Structure: Body subovate; finely granulate, dull; legs and antenna more coarsely granulate or finely rugose; labium smooth, shiny. Body above and below with dense decumbent pubescence; on head and pronotum interspersed with a few stout, longer, upright hairs; on abdominal venter with long upright hairs. Hairs nearly absent on base of pronotal macula, scutellar fovea, and posterolateral propleural macula. Head fairly strongly declivent; vertex nearly flat; ocelli much closer to eyes than to each other; eye close to anterior pronotal angle; buccula prominent, gently tapering posteriorly, not reaching anterior prosternal margin. Antennal segment I barely surpassing tip of anteclypeus. Labial segment I thickest, scarcely surpassing anterior prosternal margin, II thinner, reaching procoxa, III yet thinner, reaching mesocoxa, IV reaching metacoxa; II and III thickened distally, III and IV similar in thickness. Pronotum subquadrate; nearly flat; moderately punctate anterior to and slightly posterior to callus; lateral margin and callus slightly swollen; anterior margin slightly concave; posterior margin slightly convex; lateral margin almost straight; median carina obsolete; callar impression slightly oblique, a short posterior branch at medial end, lateral end bifid. Scutellum with low T-shaped carina; fovea in angle of T shallow, with transverse striations; lateral margin concave apically; apex acute, almost spinelike. Clavus slightly convex basally, nearly flat apically. Corium with convex costal margin, veins slightly raised. Membrane almost reaching to slightly surpassing tip of abdomen. Prosternum coarsely punctate posteriorly. Propleuron coarsely punctate, less strongly centrally, very strongly and rather elongately at posterior margin of central dark marking. Mesopleuron with deep, elongate punctations slightly posterior to midline, a few punctations in area of posterolateral macula. Metapleuron with a few indistinct punctations in area of posterolateral macula; ostiolar peritreme well developed, with evaporative area anteriorly; posterolateral angle produced; posterior margin nearly straight or slightly concave, directed anteroventrally. Abdominal sternum II almost completely covered by metapleuron; III to VII with dorsolateral gland openings; VI slightly shorter medially than laterally; VII of female cleft to base, posterior margin slightly concave laterally, curving gently to median cleft; VII of male concave posteriorly. Abdominal terga with inner and outer laterotergites II to VI well defined, VII fused and poorly separated from mediotergite; distinct apodeme present at center of inner margin of each inner laterotergite II to VI; paratergites separated from mediotergites II to VI, larger and more distinct posteriorly; mediotergites with apodemes; mediotergite VII convex in male, concave in female. Pygophore as in Figs. 69e, f; median projection well developed, bluntly rounded apically; well devel-

oped ridge on each side of median projection separated from projection by a deep narrow channel; slightly bifid projection at middle of lateral walls of dorsal opening; tergum IX reduced to narrow elongate sclerite. Clasper as in Figs. 69h-j; blade slightly curved, subtriangular in basal cross section, somewhat flattened and hemispherical in apical cross section; shank shallowly excavated anterolaterally, without dorsal overhang to excavation. Aedeagus as in Figs. 69c, g; phallotheca moderately sclerotized, phallothecal process with lateral shelflike projection, a flattened lateroventral spur basad of process; conjunctiva robust, short, with small, dorsolateral, elongate lobes distally and low lobe over ejaculatory reservoir; ejaculatory reservoir as in Figs. 69a, b, complete, with lightly sclerotized basal projection fused with membrane; vesica basally short, single large conical lobe before middle; ring sclerite thick, heavily sclerotized, narrowly incomplete basally, produced apically, lightly pigmented subapical lobe and smaller though similar apical lobe; vesica apically robust, irregularly coiled, heavily pigmented on inner margin centrally; gonoporal process short, slightly coiled, covered visibly by membrane nearly to apex; secondary gonopore flaired, with short, stout, heavily pigmented triangular process. Ovipositor as in Figs. 69k, l; first valvula almost reaching apex of connecting membrane. Spermatheca as in Fig. 69d.

Measurements: Length ♂ 6.6 (6.1-7.0), ♀ 7.2 (6.7-8.2); abdominal width ♂ 2.4 (2.1-2.5), ♀ 2.8 (2.6-3.0); head length ♂ .78 (.64-.88), ♀ .78 (.68-1.04); width across eyes ♂ 1.52 (1.44-1.56), ♀ 1.65 (1.54-1.78); pronotal length ♂ 1.42 (1.28-1.50), ♀ 1.48 (1.36-1.62); pronotal width ♂ 2.24 (2.12-2.40), ♀ 2.53 (2.32-2.72); scutellar length ♂ .98 (.84-1.08), ♀ 1.09 (1.00-1.20); scutellar width ♂ 1.26 (1.16-1.40), ♀ 1.44 (1.28-1.60); length antennal segments I ♂ .45 (.40-.48), ♀ .50 (.47-.56), II ♂ 1.05 (1.00-1.12), ♀ 1.11 (1.03-1.22), III ♂ .83 (.78-.90), ♀ .86 (.81-.96), IV ♂ 1.08 (1.04-1.16), ♀ 1.09 (1.02-1.20); length labial segments I ♂ .75 (.68-.80), ♀ .83 (.72-.90), II ♂ .64 (.56-.70), ♀ .70 (.60-.80), III ♂ .59 (.52-.68), ♀ .65 (.56-.72), IV ♂ .58 (.54-.64), ♀ .60 (.54-.68).

Comments.—This species is easily separated from other Australian Lygaeinae by the combination of short, decumbent body hairs, abdominal sternum II nearly covered by the produced posterolateral angle of the metapleuron and the white discal macula of the hemelytral membrane.

There is some variation in the extent of the black markings and in the hue of the lighter parts. In particular, the light markings on the head may be nearly completely obscured and in a few specimens all light markings are testaceous or nearly so.

Aspilocoryphus mendicus (Fabricius) from the Oriental region is similar to *A. australicus* in both color and structure but differs in that the lateral light markings of the head occupy a larger area and are not divided into two maculae on either side, the black longitudinal maculae of the pronotum are often divided behind the calli, thus forming four subquadrate maculae, and are equally dark anteriorly and posteriorly, the white discal macula of each hemelytral membrane is less rounded, and the dark borders of abdominal sterna IV to VI occupy greater areas and are produced medially to form an interrupted vitta.

The shelflike projections of the phallothecal process of *mendicus* are slightly more produced than those of *australicus* and have the distal corners more

sharply squared off, the gonoporal process is slightly thicker, the "wings" of the ejaculatory reservoir are relatively smaller, the medial projections of the lateral wall of the dorsal opening of the pygophore are more distinctly bifid, the blade of the clasper is slightly shorter and less curved and the posterolateral lobe is slightly more globular when viewed laterally. These characteristics were consistent in the specimens examined.

Nothing is known of the biology or food preferences of *Aspilocoryphus australicus*. Its distribution (Fig. 27) suggests that it prefers warm and dry conditions.

Graptostethus Stål

Lygaeus s.g. *Graptostethus* Stål, 1868: 73-74.

Graptostethus Stål, 1872:42; Slater, 1964*a*:49, 1964*b*:51; Hamid and Meher, 1973*a*:37.

Pyrrhobaphus (Graptostethus) Breddin, 1907:43 (part).

Type-species *Cimex servus* Fabricius, 1787 (fixed by Distant, 1904)

Diagnosis.—Posterolateral metapleural angle produced, nearly covering abdominal sternum II laterally; base of vertex not black, at least small pale spot present; callar impression unbranched; mesopleuron lightly punctured ante-

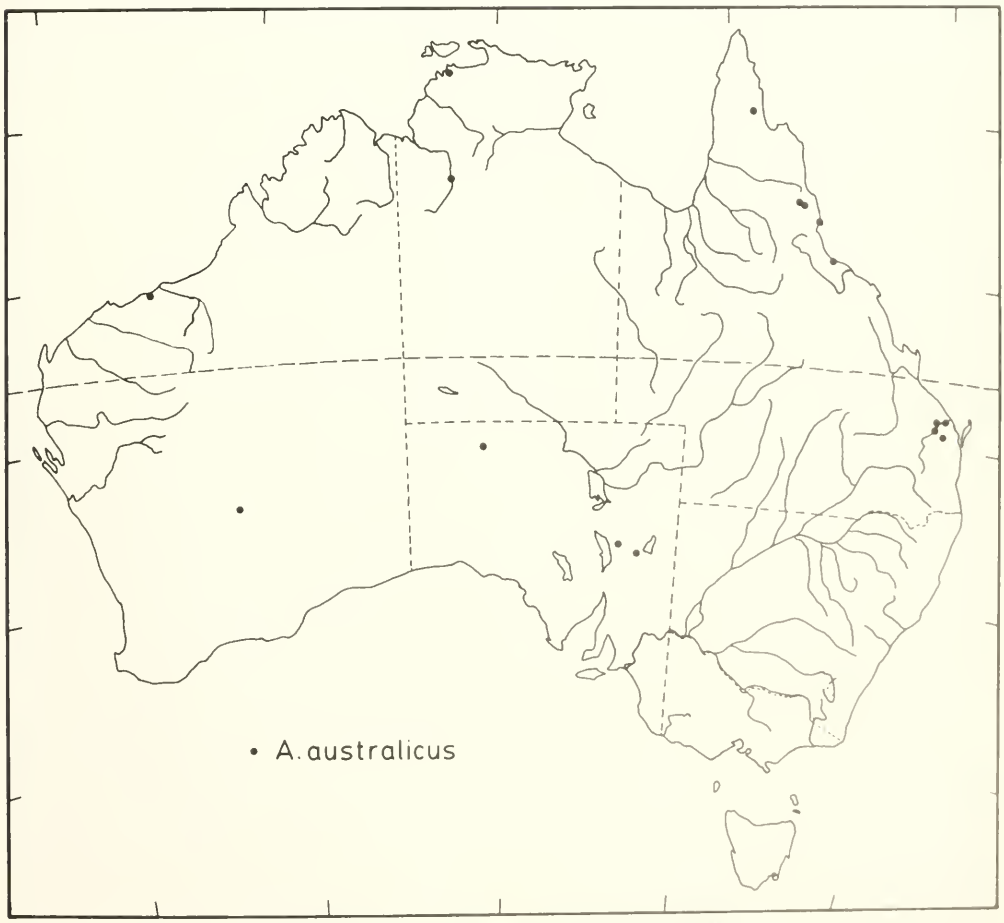


FIG. 27. Distribution of *Aspilocoryphus australicus* Stål

riorly, impunctate posteriorly; fused medio- and paratergites; and labium scarcely extending beyond metacoxa.

The genus *Aspilocoryphus* is very similar in general appearance but has distinct para- and mediotergites II to VI and the head completely black basally.

Graptostethus contains about 30 described species, all from the Eastern Hemisphere. It is primarily tropical. A complex of closely related species is present in the Oriental, Australian, and Pacific regions. Revisional work will be necessary before these species can be reliably separated. Of the four Australian species two are endemic, one also occurs in New Guinea, and the other is widespread throughout Africa, the Mediterranean region, and the Orient.

Redescription.—Color: The Australian species are for the most part quite similar in color pattern. The following description is an attempt to give a basic pattern or template from which the specific color patterns may be derived by reduction, enlargement, or fusion of the dark markings. This does not imply that it is an ancestral color pattern for the genus. *Graptostethus cardinalis* differs considerably from the pattern.

Reddish orange. The following dark brown to black: base of head behind ocellus; tip of anteclypeus; transverse pronotal bar on callus not reaching lateral margin; round macula immediately behind callus; transverse bar immediately anterior to posterior pronotal margin, interrupted medially; scutellum except apex; claval and corial margins at claval suture; small discal corial spot; short longitudinal corial vitta at base of claval suture; subrectangular macula from midpoint to near apex of costal corial margin; posterior half of prosternum; meso- and metasterna except posterior margins; rounded macula at posterolateral pleural angles; middle of propleuron; narrow fascia from middle of propleuron to prosternum just anterior of procoxa; mesopleuron except acetabula and posterior and lateral margins; metapleuron except ostiolar peritreme, acetabula, and posterior and lateral margins; abdominal venter except lateral margin; genital segments; and abdominal terga I and II. Buccula, posterior margins of meso- and metasterna, spot at base of vertex, and apical corial margin pale yellow. Hemelytral membrane dark brown, basal angle and apical margin white. Eye brown. Ocellus red. Basal angle of scutellum, base of head ventrally, thoracic sterna, and thoracic pleura except posterolateral pleural maculae and roundish anteromedial propleural area pruinose. Maculae thus appear darker than remainder of pleura.

Structure: Somewhat ovate, broad; head, thorax, and hemelytra finely granulate, dull; abdomen, antenna, labium, and legs shiny. Head moderately to strongly declivent, moderately convex; buccula prominent, sloping gradually caudad, not reaching anterior prosternal margin; ocelli much closer to eyes than to each other; eye adjacent to anterior pronotal angle. Antennal segment I surpassing anteclypeus by 1/3 to 1/2 its length; II or IV longest. Labial segment I thickest; II slightly thinner than I; III and IV about equally thick, thinner than II; I or III longest. Pronotum punctate anterior to and just behind callus; anterior margin concave (except in *G. cardinalis*); posterior margin subsinuate, slightly convex medially; lateral margin nearly straight, slightly convex and swollen posterior of callus, slightly concave anteriorly; callus slightly swollen, transverse; callar impression oblique, sinuate, unbranched; shallow transverse impression behind callus interrupted laterally

by low ridge; shallow impression at posterior margin laterad of scutellum. Scutellum acuminate; T-shaped median carina well developed; lateral fovea in angle of T shallow, transversely striate. Hemelytron incompletely covering outer laterotergites III to VI; veins moderately raised; clavus widest subapically; claval commissure from ½ to subequal in length to scutellum; costal corial margin nearly straight basally, slightly convex apically; apical corial margin straight or slightly convex. Prosternum punctate; anterior margin slightly raised. Meso- and metasterna impunctate; posterior margins raised. Propleuron heavily punctate anteriorly, lightly punctate centrally; anterior margin slightly raised. Mesopleuron sparsely, often indistinctly, punctate. Metapleuron at most very sparsely and indistinctly punctured; ostiolar peritreme well developed; posterolateral angle produced posteriorly; posterior margin convex and angled anteroventrally in dorsal ⅔, convex and directed dorsoventrally in ventral ⅓. Abdominal sternum II nearly covered by metapleuron laterally (except in *G. cardinalis*); VI of female shorter medially than laterally; VII of female cleft to base, posterior margin slightly concave lateral to cleft; VII of male concave posteriorly; sterna without dorsolateral gland openings. Abdominal terga with fused medio- and paratergites; inner and outer laterotergites II to VI distinct, VII fused and indistinctly separated from median tergite; posterior margin of male tergum VII convex medially; posterior margin of female tergum VII concave medially. Pygophore slightly concave dorsally; median projection well developed; dorsal opening laterally with ventral projection just posterior to terga, sometimes forming depressed shelf; mesally directed variously sculptured projection just anterior to insertion of clasper. Clasper with moderately to well developed caudolateral lobe; blade curved, triangular in cross section basally, flattened apically; shank deeply excavated anterolaterally, overhang developed into ventrally directed hook. Aedeagus with moderately sclerotized phallotheca; phallothecal process free distally, slightly projecting laterally; conjunctiva moderately elongate, large low lobe on each side at base, long thin lobe on each side dorsolaterally at apex; ejaculatory reservoir complete, without basal projection, covered by low membranous lobe; vesica basally robust, twisted, narrowed at ring sclerite, a large lateral lobe near ejaculatory reservoir; ring sclerite complete, wider and "cup like" apically with two elongate "corners"; vesica apically moderately coiled, slightly pigmented apically; gonoporal process moderately long, covered visibly by membrane almost to apex, less heavily pigmented distally; secondary gonopore with complex unpigmented process. Ovipositor with first valvula not reaching apex of connecting membrane; membrane connecting first valve cleft medially to level with first valvula, medial sclerite around cleft; second valvula subcylindrical apically; connecting membrane of second valve lightly pigmented, cleft almost to base. Spermatheca long, irregularly coiled, tubular, heavily pigmented except at base; sperm pump near base of pigmented area, unpigmented; no flanges.

Key to the Australian Species of Graptostethus

1. Pronotum anterior of calli, including anterior margin, black; numerous long upright hairs on hemelytra . . . . . *cardinalis* Stål
1'. Pronotum never black anterior of calli; hemelytral hairs at most

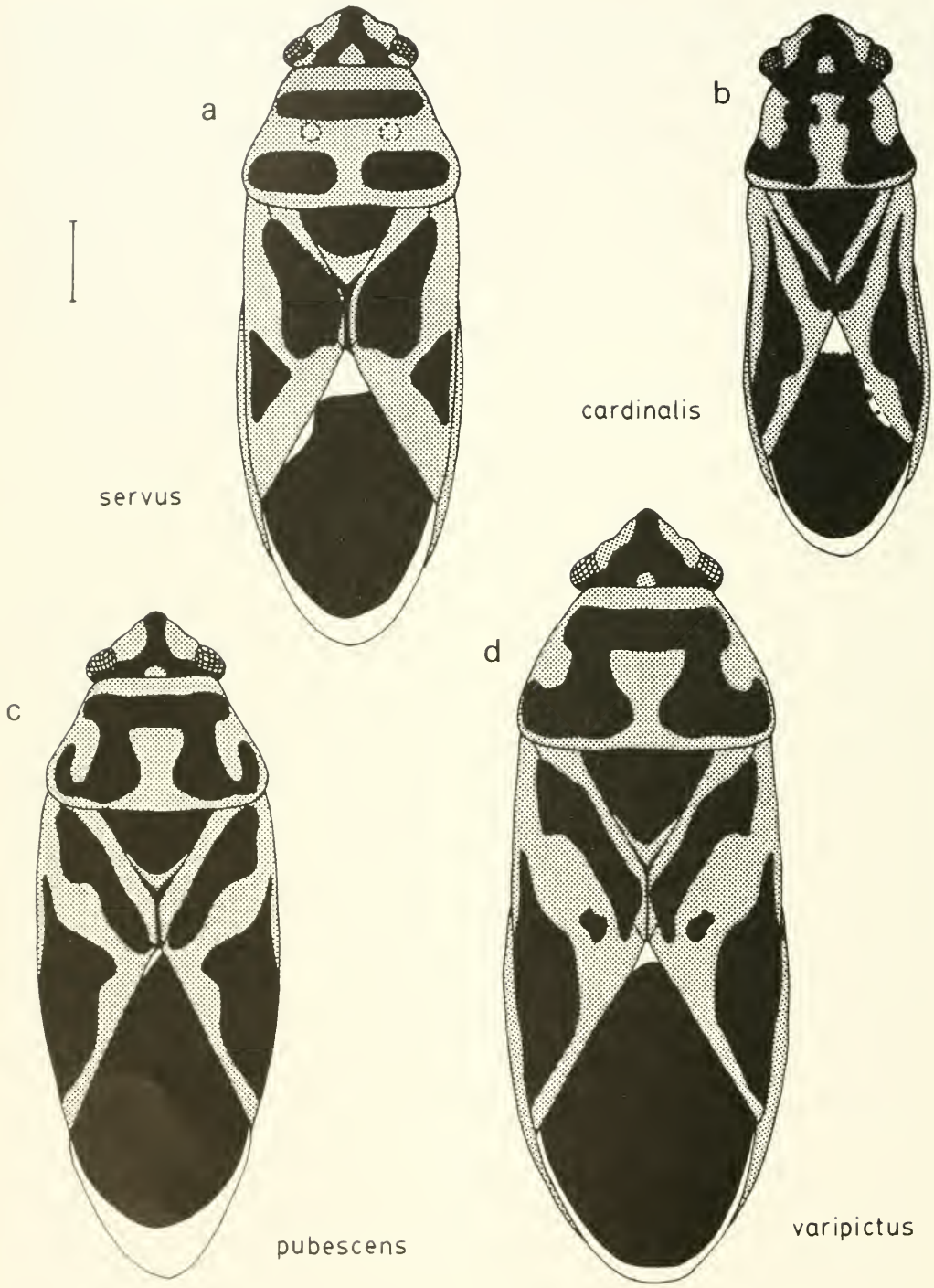


FIG. 28. *Graptostethus* spp. a-d. Dorsal view of named species. These are diagramatic representations—shape and relative size are correct but contrast between different colors has been exaggerated. All species show considerable variation in color pattern. Scale = 1 mm.

moderately long, semidecumbent 2

2. Numerous long upright hairs on pronotum and scutellum; when present, dark markings of pronotum usually not united, forming three separate maculae . . . . . *servus* (Fabricius)

2′. At most a few upright hairs of moderate length on pronotum and scutellum; when present, dark markings of pronotum usually united to form single complexly shaped macula 3

3. Dorsal hairs very short, fine, and decumbent, usually covering postcallar maculae; dark hemelytral markings always present; discal spot of corium usually not fused with other markings, if so then with costal macula . . . . . *pubescens,* sp. nov.

3′. Dorsal hairs longer, coarser, and only semidecumbent, usually absent on round postcallar maculae; dark hemelytral markings sometimes absent; discal spot of corium usually fused with dark markings of claval suture . . . . . *varipictus,* sp. nov.

Graptostethus cardinalis *(Stål 1867)*

Figures 28b; 29; 70a, b, k; 71j-l, p; 72c.

Lygaeus cardinalis Stål, 1867:163.

Graptostethus (Graptostethus) cardinalis Stål, 1874:117.

Graptostethus cardinalis. Slater, 1964*a*:50-51.

Type.—Type ♂, "Austral. boreal." "Thorey." in Stockholm.

Redescription.—Color: This species differs so markedly from the generalized generic description that a complete description is given below. Orangey red. The following dark brown to black: anteclypeus, base of head behind eye and ocellus; pronotum anterior of callus, including anterior margin, not reaching lateral margin; triangular macula behind callus, reaching lateral margin at humerus, almost reaching posterior margin and callus; scutellum except basal angle and apex; claval suture; narrow longitudinal vitta from near base of claval suture to middle of corium; broad, short vitta parallel to apical corial margin from just beyond middle of costal margin to middle of corium, connected with longitudinal vitta; hemelytral membrane except white basal angle and basal and apical margins; large rounded macula at posterolateral angle of metapleuron; posterior margins of abdominal sterna IV to VI, narrowly medially, broadly forming interrupted vitta laterally, not reaching lateral margin; abdominal sternum VII except lateral margin; genital segments; antennal segments II to IV and apex of I; labial segments II to IV and I apically and ventrally; apex of femora; tibiae; and tarsi. Eye dark brown. Ocellus red. Thoracic sterna infuscated except pallid posterior margins. Thoracic pleura infuscated except dorsal (lateral) margins. Ostiolar peritreme pallid basally, bright reddish orange apically.

Structure: Narrow for genus. Body clothed moderately densely with long, fine, upright hairs; body except scutellum and disc of posterior pronotal lobe each side of middle densely covered with moderately long semidecumbent hairs, sparse on head, pronotum anterior of callus, and region of longitudinal corial vitta, shorter on abdominal venter. Head strongly declivent, slightly swollen immediately anterior of eye; buccula reaching or almost reaching anterior prosternal margin; eye slightly removed from anterior pronotal angle. Antennal segment I surpass-

ing apex of anteclypeus by about half its length. Labial segment I reaching anterior prosternal margin, II reaching procoxa, III reaching about middle of mesosternum, IV reaching metasternum. Pronotum very strongly punctured anterior to and immediately behind callus, slightly constricted and impressed behind callus; anterior margin straight; lateral margin slightly convex anteriorly and posteriorly; callus moderately swollen. Hemelytral membrane almost reaching abdominal apex. Propleuron coarsely punctate anteriorly and posteriorly, impunctate medially. Mesopleuron with few very indistinct punctures. Metapleuron impunctate. Pygophore as in Fig. 70k; ventral projection of side of dorsal opening invisible from above; lateral projection broadly bifid, dorsal channel absent. Clasper as in Figs. 71j-l; posterolateral lobe short; lateral hook well developed, very acute apically. Aedeagus as in generic description; ejaculatory reservoir as in Figs. 70a, b. Ovipositor as in Fig. 71p; first valvula surpassing first ramus. Spermatheca as in Fig. 72c; fairly short; sclerotized part basad of sperm pump moderately long.

Measurements: 6♂, 3♀. Length ♂ 6.8 (6.2-7.0), ♀ 7.3 (7.1-7.5); abdominal width ♂ 2.2 (2.0-2.4), ♀ 2.7 (2.7-2.8); head length ♂ .72 (.64-.78), ♀ .67 (.58-.76); width across eyes ♂ 1.67 (1.56-1.72), ♀ 1.79 (1.76-1.82); pronotal length ♂ 1.58 (1.44-1.70), ♀ 1.61 (1.56-1.64); pronotal width ♂ 2.23 (2.04-2.32), ♀ 2.57 (2.48-2.62); scutellar length ♂ 1.01 (.90-1.08), ♀ 1.24 (1.20-1.30); scutellar width ♂ 1.17 (1.04-1.28), ♀ 1.37 (1.36-1.40); length antennal segments I ♂ .46 (.43-.51), ♀ .50 (.49-.50), II ♂ 1.04 (.94-1.10), ♀ 1.10 (1.09-1.12), III ♂ .85 (.76-.92), ♀ .90 (.87-.92), IV ♂ 1.28 (1.16-1.36), ♀ 1.27 (1.20-1.31); length labial segments I ♂ .72 (.64-.84), ♀ .78 (.76-.80), II ♂ .61 (.58-.66), ♀ .69 (.68-.70), III ♂ .64 (.60-.68), ♀ .73 (.70-.76), IV ♂ .66 (.64-.70), ♀ .70 (.66-.72).

Comments.—The black anterior pronotal margin, constricted pronotum, and the long upright hairs on the hemelytra separate this from all other species in the genus. The only other *Graptostethus* with dark anterior pronotal markings are large, with the typical generic pronotal shape, and only short semidecumbent hairs on the hemelytra.

As mentioned above, *G. cardinalis* differs markedly from the usual external appearance of the genus. The genitalia are, however, typical of the genus and there can be no doubt that it is correctly placed. The dark markings are often reduced in size and in intensity but the anterior pronotal area, subapical corial vitta, and black posterolateral pleural maculae were present in all specimens examined.

Graptostethus cardinalis is uncommon in collections but appears to be widely distributed in the northern half of Australia (Fig. 29). Nothing is known of its food plant or biology.

Graptostethus pubescens, *sp. nov.*

Figures 28c; 29; 70e, f, j; 71a-c, m; 72b, g, h.

Types.—Holotype ♀, "1 km. N. of Cahill's Crossing (East Alligator R.), 12.25 S, 132.58 E, 31-X-1972. M Upton." in ANIC. Paratypes: 4♂, 6♀, same data as holotype, in ANIC. Also: Northern Territory—2♂, 1♀, Adelaide River, 13.15S, 131.06E, 17.x.1972, Upton and Barrett; 5♂, 4♀, 1 km N of Cahill's Crossing, 12.25S, 132.58E, 8.xi. 1972, Upton and Feehan; 2♂, 4♀, 1 km N of Cahill's Xing, (E. Alligator R.), 12.25S, 132.58E, 8-9.xi.1972,

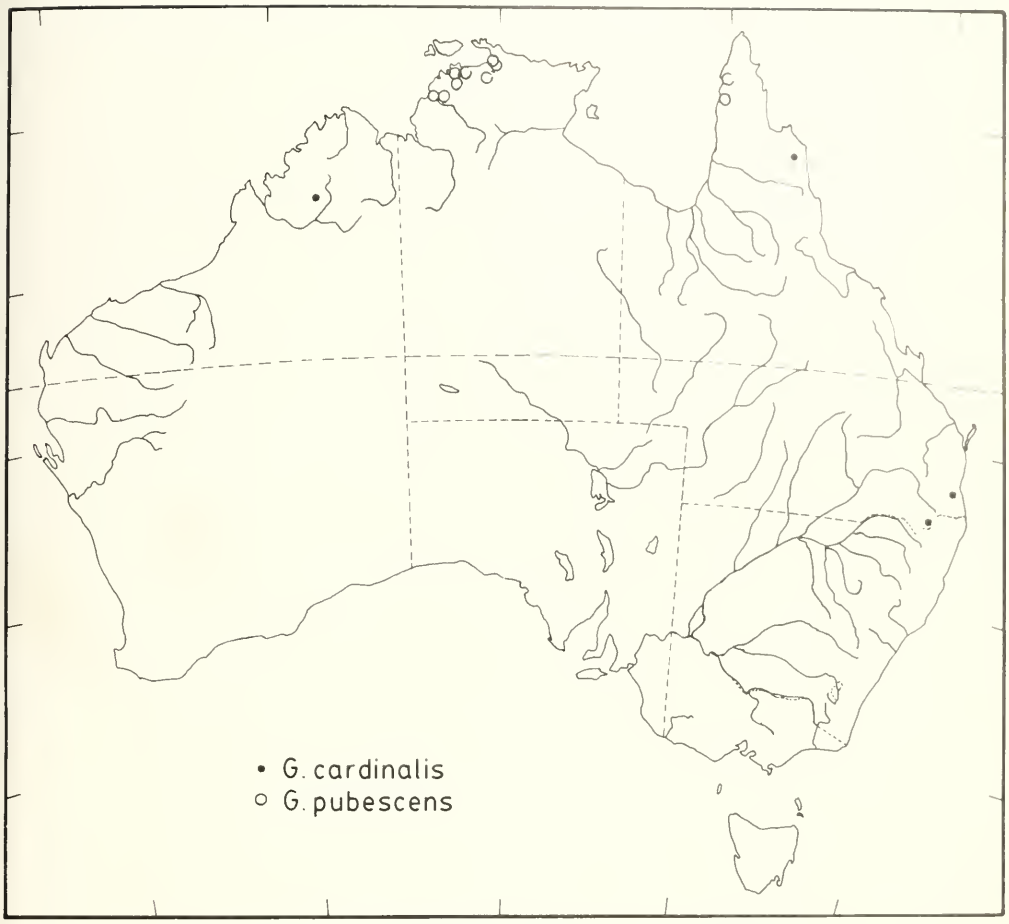


FIG. 29. Distribution of *Graptostethus cardinalis* Stål and *G. pubescens*, sp. nov.

J. C. Cardale; 1♀, 1 km S of Cahill's Xing, 12.26S, 132.58E, 3.xi.1972, Upton and Barrett; 2♀, 5 km NNW of Cahill's Crossing, East Alligator River, 12.23S, 132.57E, 8.vi.1973, R. L. Kitching; 2♂, 5 km NNW of Cahill's Crossing, East Alligator River, 12.23S, 132.57E, 8.vi.1973, R. L. Kitching, at light; 1♂, 1♀, Daly River Mission, 15.vi.1974, J. F. Hutchinson; 1♀, Darwin, Nightcliff, 20.viii.1956, L. D. Crawford; 1♀, Howard Springs, 4.iii.1967, M. S. Upton; 2♀, Humpty Doo, 15.vi.1961, C. S. Li, cat #16; 1♀, 14 mi W Humpty Doo, 14.vi.1964, K. R. Norris; 2♂, 2♀, 7 km SE of Litchfield Hmstd, 13.iii.1974, J. F. Hutchinson; 1♂, Magela Ck., 9 km SSE of Mudginberri H. S., 12.40S, 132.54E, 6.xi.1972, M. Upton; 1♂, Magela Ck., 2 km N of Mudginberri H. S., 12.35S, 132.52E, 14.xi.1972, M. Upton; 2♂, 3♀, Nourbangie Ck., 8 km N of Mt. Cahill, 12.48S, 132.42E, 21.v.1973, Upton and McInnes; 1♂, 6 km SW by S of Oenpelli, 12.22S, 133.01E, 30.v.1973, Upton and McInnes (ANIC); 2♀, Daly Riv. Mission, 22.i.1972, J. F. Hutchinson; 1♀, 30 mi E. Darwin, 12.xii.1923, G. F. Hill; 1♀,

Oenpelli, xii.1918, D. P. Cahill (NMV); 1♀, Humpty Doo, 21.vi. 1956, L. O. Crawford (PIBNTA); 2♂, 3♀, Daly River, 30.vi.1972, B. K. Head, on low bushes by river; 2♀, Darwin; 1♀, Koolpinyah, October, G. F. Hill; 1♀, Roper R. (SAM); Queensland—1♀, Archer R., 27.vi.196?, C. N. Smithers (AM); 2♀, Weipa, 3-5.ii.1976, G. B. Monteith, open forest (UQ).

Description.—Color: Orange, darkest on head and abdomen, brighter on anterior pronotal lobe and thoracic venter, tawny on posterior pronotal lobe and coriaceous parts of hemelytron. Differs from general generic coloration in that: gular area infuscated; posterior transverse pronotal bar produced forward to meet round postcallar macula, forming triangular macula on each side of pronotum; longitudinally ovate humeral macula connected with lateral end of triangular macula; round posterolateral pleural maculae poorly defined, no darker than other dark markings; narrow dark orange posterior margins on all abdominal sterna; white mark at basal angle of hemelytral membrane small, obscure; apical margin of corium usually tawny orange. Antenna dark brown except segment I and sometimes II orangey brown. Labium brown becoming darker apically. Coxae, trochanters, and femora orangey brown. Tibiae and tarsi dark brown. All dark areas appear more brown than black.

Structure: Moderately robust; densely clothed with very short, fine, decumbent hairs, slightly longer and more upright posteriorly on meso- and metapleura, interspersed with a few very short upright hairs dorsally on head and pronotum, interspersed with long upright hairs medially on abdominal venter. Head moderately declivent. Antennal segment I surpassing anteclypeus by about 1/3 its length. Labial segment I slightly thicker than II; II slightly thicker than III and IV; I surpassing anterior prosternal margin by about 1/4 its length; II reaching just beyond middle procoxa; III almost reaching posterior margin of mesocoxa; IV reaching posterior metacoxal margin. Hemelytral membrane greatly surpassing tip of abdomen. Prosternum shallowly punctured anteriorly, impunctate posteriorly. Propleuron shallowly punctured anteriorly; indistinctly punctate centrally; impunctate posteriorly. Mesopleuron very indistinctly punctate. Pygophore as in Fig. 70j; ventral projection of side of dorsal opening scarcely visible from above; lateral projection without anterior point, dorsal channel shallow. Clasper as in Figs. 71a-c; posterolateral lobe short; hook short, rather blunt. Aedeagus as in generic description; ejaculatory reservoir as in Figs. 70e, f. Ovipositor as in Figs. 71m, 72g, h; first valvula surpassed distally by first ramus. Spermatheca as in Fig. 72b; thin; sclerotized part basal to sperm pump relatively long.

Measurements: Length ♂ 8.4 (7.8-9.1) ♀ 8.8 (8.5-9.2); abdominal width ♂ 2.8 (2.7-3.1), ♀ 3.1 (2.9-3.4); head length ♂ .77 (.66-.85), ♀ .80 (.68-.89); width across eyes ♂ 1.76 (1.65-1.83), ♀ 1.80 (1.75-1.88); pronotal length ♂ 1.62 (1.51-1.81), ♀ 1.69 (1.58-1.78); pronotal width ♂ 2.80 (2.58-3.05), ♀ 2.94 (2.84-3.11); scutellar length ♂ 1.22 (1.11-1.30), ♀ 1.29 (1.10-1.38); scutellar width ♂ 1.52 (1.35-1.70), ♀ 1.60 (1.48-1.73); length antennal segments I ♂ .59 (.56-.61), ♀ .58 (.56-.61), II ♂ 1.37 (1.30-1.45), ♀ 1.36 (1.31-1.45), III ♂ 1.00 (.95-1.07), ♀ .98 (.95-1.04), IV ♂ 1.30 (1.25-1.36), ♀ 1.26 (1.19-1.31); length labial segments I ♂ 1.04 (1.01-1.06), ♀ 1.08

(1.03-1.14), II ♂ .97 (.95-1.00), ♀ 1.01 (.96-1.04), III ♂ 1.06 (1.00-1.10), ♀ 1.11 (1.06-1.18), IV ♂ .81 (.79-.85), ♀ .86 (.83-.90).

Measurements holotype ♀. Length 8.8; abdominal width 3.1; head length .74; width across eyes 1.78; pronotal length 1.69; pronotal width 2.96; scutellar length 1.31; scutellar width 1.63; length antennal segments I .59, II 1.45, III 1.04, IV 1.29; length labial segments I 1.13, II 1.04, III 1.13, IV .90.

Comments.—*Graptostethus pubescens* may be separated from other Australian members of the genus by the very short decumbent hairs with no interspersed long upright hairs. It resembles Australian specimens of *G. servus* in the generally faded appearance of the color pattern but is more orange than reddish in color. *Graptostethus varipictus,* sp. nov., has much more distinct dark markings and is more brightly colored in general.

Some specimens have greatly reduced dark markings both in intensity and in area covered. The head, pronotum, and thoracic venter are especially affected. The dark discal spot on the corium is seldom fused with other dark areas but if fused then fused with the costal macula not the dark margin of the claval suture.

Graptostethus pubescens is nearly restricted to the northern part of the Northern Territory (Fig. 29) with a few specimens taken on the western coastal part of the Cape York Peninsula. Nothing is known of its food plant or biology.

Graptostethus servus *(Fabricius 1787)*

Figures 28a; 30; 70c, d, l, m; 71d-f, o; 72a, e, f, i, j.

Cimex servus Fabricius, 1787:300.
Lygaeus servus Fabricius, 1794:156.
Lygaeus manillensis Stål, 1859:240-241; Slater, 1978:855.
Lygaeus ornatus Uhler, 1860:227.
Lygaeus (Graptostethus) servus Stål, 1868: 74-75.
Graptostethus (Graptostethus) servus Stål, 1874:117.
Graptostethus servus Slater, 1964*a*:57-59.

Type.—Not seen. Type locality given by Fabricius as China.

Redescription.—Color: Pale orangey red, dark areas appearing heavily infuscated rather than black. Differs from general generic coloration in that: head completely reddish except dark median longitudinal vitta from base to apex of anteclypeus, broader to surround ocelli basally; round postcallar macula very light or absent, indicated by hairless area causing it to appear darker than surrounding areas; posterior pronotal bar very light or absent; dark margin of claval suture frequently expanded to include short basal corial vitta and discal corial spot, sometimes fused with costal macula to form oblique vitta across corium; prosternum completely reddish; major dark areas of thoracic pleura scarcely infuscated; posterolateral maculae of all thoracic pleura and anterior propleural macula indicated only by absence of pruinosity; posterior margins of abdominal sterna IV to VII, sternum II completely, and genital segments pale orange; apical margin of corium with broad pallid border; basal angle of hemelytral membrane and broad apical margin white. Antenna and labium brown. Legs orangey brown, becoming darker apically.

Structure: Body moderately robust; densely clothed with fairly short semidecumbent hairs interspersed (except on hemelytra) with long nearly upright hairs (these densest on head, callus, lateral pronotal margin, scutellum, and

medially on abdominal venter); short decumbent hairs lacking on round postcallar macula, thoracic sterna, meso- and metapleura posteriorly; hairs somewhat more upright on hemelytra. Head moderately declivent; buccula almost reaching anterior prosternal margin. Antennal segment I surpassing anteclypeus by about 1/3 its length. Labial segment I slightly thicker than II, II thicker than III and IV; I surpassing anterior prosternal margin by about 1/5 its length, II reaching middle of procoxa, III reaching middle of mesocoxa, IV reaching middle of metacoxa. Hemelytral membrane slightly surpassing tip of abdomen. Prosternum moderately coarsely punctate anteriorly, impunctate posteriorly. Propleuron moderately coarsely punctate anteriorly, finely but distinctly punctate centrally, indistinctly punctate or impunctate posteriorly. Mesopleuron sparsely, finely, but distinctly punctate. Pygophore as in Figs. 77a, b; ventral projection of sides of dorsal opening not or scarcely visible from above; lateral projection slightly bifid, dorsal channel distinct. Clasper as in Figs. 71d-f; posterolateral lobe well developed, directed somewhat dorsad; shank very deeply excavated, hook very strongly developed, blunt apically. Aedeagus as in Fig. 72e, f; ejaculatory reservoir as in Figs. 70c, d. Ovipositor as in Figs. 71o, 72i, j; first valvula surpassing first ramus distally. Spermatheca as in Fig. 72a; sclerotized part basad of sperm pump relatively short.

Measurements: Length ♂ 8.6 (7.9-9.2), ♀ 9.0 (7.9-9.9); abdominal width ♂ 2.8 (2.7-3.0), ♀ 3.2 (2.7-3.5); head length ♂ .78 (.61-.88), ♀ .80 (.64-.99); width across eyes ♂ 1.81 (1.78-1.88), ♀ 1.90 (1.76-2.00); pronotal length ♂ 1.80 (1.63-1.98), ♀ 1.82 (1.58-2.01); pronotal width ♂ 2.86 (2.74-3.04), ♀ 3.05 (2.64-3.39); scutellar length ♂ 1.20 (1.11-1.40), ♀ 1.35 (1.15-1.55); scutellar width ♂ 1.49 (1.39-1.70), ♀ 1.69 (1.45-1.90); length antennal segments I ♂ .58 (.54-.62), ♀ .59 (.56-.64), II ♂ 1.37 (1.28-1.47), ♀ 1.36 (1.26-1.43), III ♂ 1.00 (.93-1.06), ♀ .99 (.93-1.09), IV ♂ 1.39 (1.28-1.51), ♀ 1.36 (1.26-1.43); length labial segments I ♂ .98 (.95-1.05), ♀ 1.01 (.94-1.06), II ♂ .94 (.86-1.03), ♀ .96 (.88-1.01), III ♂ .98 (.88-1.08), ♀ 1.02 (.94-1.08), IV ♂ .82 (.78-.88), ♀ .85 (.79-.90).

Comments.—The dark median longitudinal vitta on the head separates *G. servus* from all other Australian members of the genus. The numerous long upright hairs, which give the pronotum a shaggy appearance from above, separate it from all except *G. cardinalis* which has the pronotum constricted behind the calli and a quite different color pattern. Australian specimens differ from typical *G. servus* in their generally paler coloration. Occasional individuals approach the coloring typical of *servus* in India and the Orient. Specimens from Saibai Island, York Island, and Moa Island in the Torres Strait have the darker typical coloration as do occasional specimens from the Northern Territory. These darker individuals may indicate gene flow from populations of the species in New Guinea and Timor, respectively.

Graptostethus servus is widely distributed throughout Africa, the Mediterranean region and the Orient. In Australia it is mainly northern in distribution (Fig. 30). Nothing is known of its biology or food plant preferences in Australia. Slater (1964*b*:54) has summarized host plant data for the entire range. Hoffman (1934) recorded the life history of "*Graptostethus* sp. near *servus* F.", which may be this species, in China.

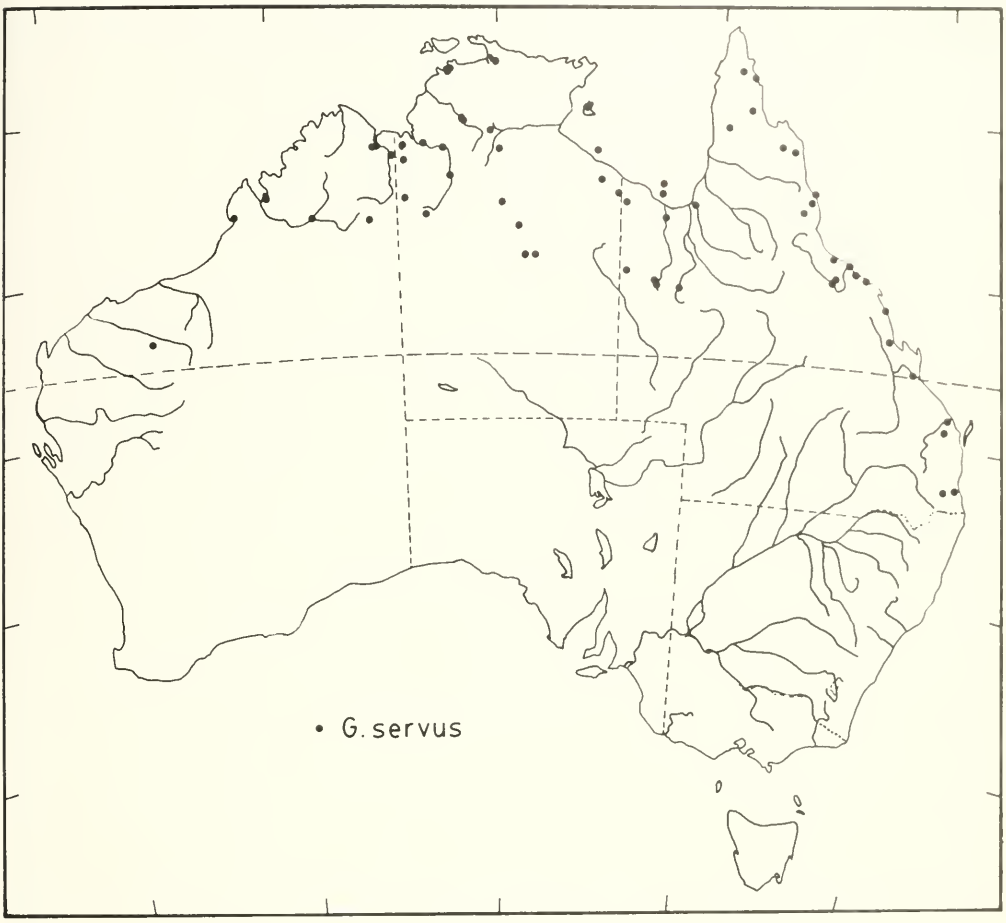


FIG. 30. Distribution of *Graptostethus servus* (Fabricius) in Australia.

Graptostethus varipictus, *sp. nov.*

Figures 28d; 31; 70g-i; 71g-i, n; 72d.

Types.—Holotype ♀, "Queensland, Brisbane, 23-III-1964. R. Kumar." in ANIC. Paratypes: 1♀, same data as holotype, in ANIC. Also: Victoria—1♂, Woodonga (NMV); New South Wales—3♀, Brunswick Heads, 9.ii.1962, D. E. Haverstein (ANIC); 1♀, Broadwater, iii.1924, E. G. Baber; 1♀, Broadwater, iii. 1924, D. S. North; 1♀, Broadwater, iv.1924, E. G. Baber (AM); Northern Territory—1♂, Jim Jim Waterhole, 12.57S, 137.34E, 28.viii.1970, J. V. Peters (AM); 1♀, Darwin, Nightcliff, 20.viii.1956, L. D. Crawford; 1♂, Nourlangie Ck., 8 km N of Mt. Cahill, 12.48S, 132.42E, 21.v. 1973, Upton and McInnes; 1♂, 6 km SW of S of Oenpelli, 12.22S, 133.01E, 30.v.1973, Upton and McInnes (ANIC); 1♀, (no locality), vii-viii.12, from Prof. Spencer (NMV); 1♂, Groote Eylandt, Connexion I., N. B. Tindale; 2♀, Roper R., N. B. Tindale (SAM); 1♂, Pine Creek, 22.xi.1974, E. M. Exley and R. I. Storey, on *Eucalyptus tectifica* (UQ); Queensland—2♂, Brisbane, 23.iii.1964, R. Kumar; 1♀, Bundaberg, 2.xi.1971, H. Frauca; 1♂, Bundaberg, 16.x.1974, H. Frauca;

1♂, 1♀, Bundaberg, 17.x.1974, H. Frauca; 1♂, Moreton I., Big Sand Hill, 3.iv.1966, T. G. Campbell (ANIC); 1♂, Bentinck I., 27.v.1960, P. Aitken, N. Tindale, at light; 1♂, Cairns, A. M. Lea (SAM); 2♀, nr. Red Cliff Pt. N of Cairns, 21.vi. 1971, E. C. Dahms (QM); 2♂, Mackay, Far Beach, 5.vi.1971, E. C. Dahms; 1♀, Pallarenda Pt., nr. Townsville, 26.i.1965, E. C. Dahms, open forest, nets (QM); 1♀, Bamaga, Cape York, 3-6.vi.1969, G. B. Monteith; 1♂, Brisbane, 14. vii.1932; 1♂, Brisbane, 17.iii.1970, M. B. Malipatil; 1♀, Brisbane, R. Kumar; 1♂, Brisbane, Long Pocket, 8.viii.1976, A. Slater; 1♂, Calamvale, Johnston's Road, 23.xi.1975, R. I. Storey; 1♀, Captain Billy Ck., Cape York Pen., 142.50E, 11.40S, 9-13.vii.1975, G. B. Monteith; 1♂, Dunk I., 25.viii.1927; 3♂, 5♀, Mareeba, 28.i.1976, R. I. Storey, on rose flowers; 1♀, Mission Beach, 21. v.1976, R. I. Storey; 3♂, 2♀, Dunwich, Stradbroke I., 21-22.iii.1970, M. B. Malipatil (UQ).

Description.—Color: Bright reddish orange, apex of scutellum and coriaceous parts of hemelytra pales. Dark areas black. Differing from general generic description in that: the entire head dark ventrally except buccula; posterior transverse pronotal bar extended anteriorly, forming subtriangular macula by fusion with round postcallar macula, produced slightly anteriorly at humerus; round postcallar macula appearing darker than surroundings due to lack of hairs; apical 1/3-1/2 of raised lateral scutellar margin and apex orange; discal spot on corium fused with dark margin of claval suture; metapleural markings include anterior half of acetabular area. White mark at basal angle of hemelytral membrane small, indistinct. Posterolateral maculae of thoracic pleura distinct, fused with dark central markings, about equal in size. Antenna, labium, and legs dark brown. Apical margin of corium often with narrow pale border.

Structure: Body robust; clothed densely with shortish, rather coarse, semidecumbent hairs, these usually absent on postcallar macula; a few upright or nearly upright hairs of similar length on pronotum and scutellum, most noticeable at lateral margin of pronotum at callus; meso- and metapleural hairs becoming longer and more upright posteriorly; scattered long nearly upright hairs, densest medially, on abdominal venter. Head moderately declivent. Antennal segment I surpassing anteclypeus by about 1/3 its length. Labial segment I thickest, II slightly thinner, III and IV slightly thinner than II; I surpassing anterior prosternal margin by about 1/5 its length, II reaching posterior margin of procoxa, III extending slightly beyond middle of mesocoxa, IV reaching or slightly surpassing posterior margin of metacoxa. Hemelytral membrane reaching or slightly surpassing tip of abdomen. Prosternum coarsely punctate anteriorly, indistinctly punctate or impunctate posteriorly. Propleuron coarsely punctate anteriorly, finely but distinctly punctate centrally, indistinctly punctate or impunctate posteriorly. Mesopleuron moderately finely, distinctly punctate. Metapleuron with posterior margin slightly convex dorsally and ventrally. Pygophore as in Fig. 70i; ventral projection of lateral margin of dorsal opening visible from above, forming depressed shelf; lateral projection deeply bifid, anterior point curving posterad to form slight apical lip, dorsal channel distinct. Clasper as in Figs. 71g-i; posterolateral lobe with

slight lump dorsally, not directed dorsally; hook short, broad. Aedeagus similar to *G. servus* (Fig. 72e); ejaculatory reservoir as in Figs. 70g, h. Ovipositor as in Fig. 71n; first valvula surpassed by first ramus. Spermatheca as in Fig. 72d; thick; slightly thickened subapically; pigmented part basal to sperm pump of medium length.

Measurements: Length ♂ 8.8 (8.4-9.4), ♀ 10.1 (9.2-10.9); abdominal width ♂ 3.1 (3.0-3.3), ♀ 3.6 (3.2-3.8); head length ♂ .82 (.68-.96), ♀ .92 (.83-1.10); width across eyes ♂ 1.86 (1.79-1.93), ♀ 2.05 (1.88-2.14); pronotal length ♂ 1.75 (1.54-1.94), ♀ 2.00 (1.78-2.18); pronotal width ♂ 3.01 (2.93-3.21), ♀ 3.53 (3.15-3.73); scutellar length ♂ 1.26 (1.21-1.33), ♀ 1.48 (1.38-1.53); scutellar width ♂ 1.63 (1.55-1.74), ♀ 1.97 (1.76-2.13); length antennal segments I ♂ .65 (.63-.69), ♀ .69 (.65-.72), II ♂ 1.55 (1.40-1.66), ♀ 1.67 (1.53-1.88), III ♂ 1.15 (1.08-1.23), ♀ 1.22 (1.09-1.38), IV ♂ 1.62 (1.58-1.66), ♀ 1.65 (1.56-1.74); length labial segments I ♂ 1.14 (1.08-1.20), ♀ 1.28 (1.18-1.34), II ♂ 1.11 (1.04-1.19), ♀ 1.22 (1.08-1.30), III ♂ 1.26 (1.16-1.39), ♀ 1.39 (1.25-1.53), IV ♂ .98 (.90-1.04), ♀ 1.06 (.98-1.13).

Measurements holotype ♀. Length 10.9; abdominal width 3.8; head length .96; width across eyes 2.14; pronotal length 2.15; pronotal width 3.66; scutellar length 1.63; scutellar width 1.95; length antennal segments I .72, II 1.71, III 1.23, IV 1.68; length labial segments I 1.28, II 1.24, III 1.53, IV 1.03.

Comments. — *Graptostethus varipictus* can be distinguished from other Australian members of the genus by the large size, labium extending to or beyond the hind coxae, and the short hairs interspersed with slightly longer upright hairs on pronotum and scutellum. The species is named for the variability shown in its color pattern.

The color pattern of this species is extremely variable. In very dark specimens nearly the entire posterior lobe of the pronotum and entire corium are dark. The pale spot at the base of the vertex, often used in the past as a generic character, is sometimes absent. In lighter specimens the head may be almost completely orange, the black areas of the pronotum are present only as infuscations much reduced in area, and the scutellum is black only at the basal angles. A distinctive color form lacks any dark markings on the clavus and corium and has the posterior dark pronotal markings reduced to a narrow longitudinal vitta from the round postcallar macula nearly to the posterior margin and an indistinct spot at the humerus on each side.

Graptostethus varipictus is restricted, in Australia, to the northern and eastern coastal regions, the range extending south to about the Queensland-New South Wales border (Fig. 31). I have also seen specimens from Papua New Guinea. Malipatil (1979) provides brief life history and food plant notes. Adults were taken on rose flowers in northern Queensland by Mr. R. I. Storey.

Three *Graptostethus* specimens from New Caledonia (in the collection of the Bishop Museum) matching the original description of *G. ocellatus* (Montrouzier) are very similar to the form of *G. varipictus* with unmarked hemelytra. They differ in their smaller size, the presence of pallid areas rather than orange markings ventrally on the thoracic pleura, a comparatively slightly longer labium, slight differences in the shape of the claspers (especially the posterolateral lobe which is directed somewhat dorsad) and the less distinct channel of the lateral projection of the dorsal pygophore opening. The differ-

ences except in size are slight and it is possible that study of a larger series from New Caledonia would show the two species to be one.

Some specimens of *G. nigriceps* Stål, *G. diffusus* (Walker), and *G. manillensis* (Usinger *nec* Stål) also lack claval and corial markings. The first is smaller, lacks upright hairs on the pronotum and scutellum, and has a relatively much longer labium. The second has longer and more numerous upright hairs on the pronotum and scutellum (approaching *G. servus* in this respect) and pale yellow rather than orange markings on the thoracic pleura. The last has nearly obsolete dark markings on the thoracic pleura except for the very distinct posterolateral maculae and a similar macula anteriorly on each propleuron; the abdominal venter is nearly uniform brownish orange. Darker specimens of *G. nigriceps* usually have the corium except for very narrow margins infuscated. Dark specimens of *G. diffusus* and *G. manillensis* (Usinger *nec* Stål) have the discal macula and abbreviated longitudinal vitta of the corium fused with a very broad dark margin of the claval suture, thus appearing to have two large clearly defined maculae on each hemelytron. Records of *G. manillensis* and *G. nigriceps* from Australia almost certainly refer to *G. varipictus*.

Pyrrhobaphus Stål

Lygaeus s.g. *Pyrrhobaphus* Stål, 1868: 73.

Pyrrhobaphus Stål, 1874:99, 116; Slater, 1964*a*:187.

Type-species *Cimex leucurus* Fabricius, 1787, monobasic.

Stål (1868) erected this genus and the genus *Graptostethus* as subgenera of the omnibus genus *Lygaeus* Fabricius. His descriptions of the two subgenera are nearly identical, *Pyrrhobaphus* being separated from *Graptostethus* by the possession of relatively longer antenna and labium. Breddin (1905:121) pointed out that the discovery of species unknown to Stål, with the general appearance of *P. leucurus* (the type species of *Pyrrhobaphus*) but possessing characters intermediate between that species and members of *Graptostethus,* invalidated Stål's division between the two groups. He treated *Graptostethus* as a junior synonym of *Pyrrhobaphus* on the basis of line priority. No author since Breddin has followed his synonymy. Of the species placed in *Pyrrhobaphus* by Breddin those species closely resembling *P. leucurus* in color or not readily placed in *Graptostethus* on the basis of their original description have been treated as members of *Pyrrhobaphus*. The large number of species, some of them widespread, corresponding more closely to Stål's description of *Graptostethus* than to his description of *Pyrrhobaphus,* have been described and discussed under the generic name *Graptostethus*.

I have closely examined specimens of *P. leucurus,* including the male and female genitalia, and can find no consistent generic differences between it and members of *Graptostethus*. As it would create confusion to revert to Breddin's synonymy at this time, I am treating the two genera as separate pending an appeal to the International Commission on Zoological Nomenclature for the conservation of *Graptostethus* as the generic name for those species now contained in *Graptostethus* and *Pyrrhobaphus*.

The generic description given for *Graptostethus* applies to *P. leucurus,* the single Australian member of *Pyrrhobaphus,* except that in *P. leucurus* the head is only slightly declivent, the labium extends well beyond the metacoxae, and the color pattern is quite different.

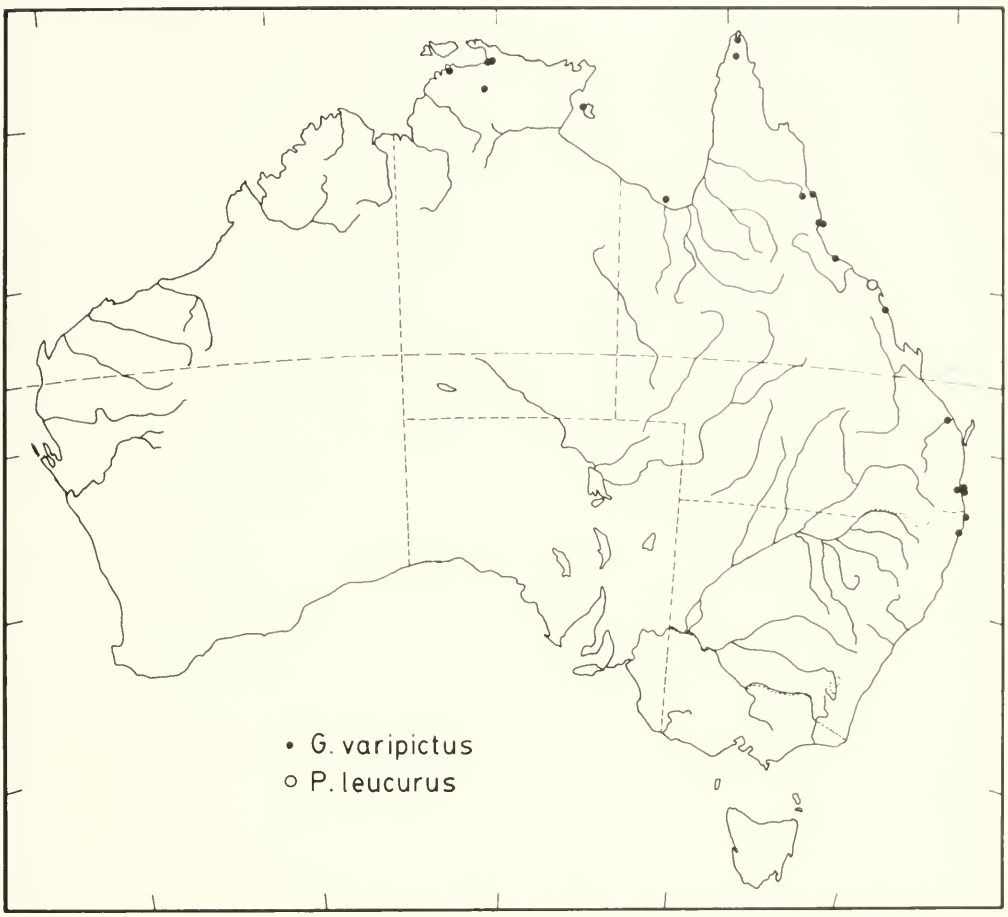


Fig. 31. Distribution of *Graptostethus varipictus*, sp. nov. and *Pyrrhobaphus leucurus* (Fabricius) in Australia.

Pyrrhobaphus leucurus
(Fabricius 1787)

Figures 31; 32; 73a-i; 74a-d.

Cimex leucurus Fabricius, 1787:299.
Lygaeus leucurus Fabricius, 1794:154.
Lygaeus (Pyrrhobaphus) leucurus Stål, 1868:73.
Pyrrhobaphus leucurus Stål, 1874:116; Slater, 1964*a*:188; Slater, 1978:856-857.

Types.—Lectotype ♀, "Is. Amsterdam" in BMNH (Banks Collection). Paralectotype ♂, same data as lectotype, in BMNH (Banks Collection).

Redescription.—Color: Dark reddish orange. The following black: base of head; tip of anteclypeus; gular area; pronotum except broad lateral margin behind callus; scutellum; thoracic sterna and pleura except posterolateral angles of pro- and metapleura and narrow dorsal margin of mesopleuron; abdominal sterna except broad lateral margins; genital segments; fused medio- and paratergites; antenna except basal ⅔ of segment I; labium; and legs. Basal ⅔ of antennal segment I light brown. Eye brown. Ocellus orange. Hemelytral membrane dark brown to black except white basal angle and narrow whitish margin widest apically.

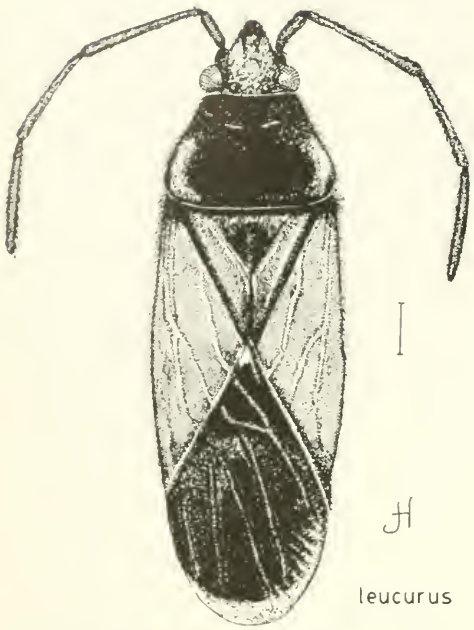


FIG. 32. *Pyrrhobaphus leucurus* (Fabricius), dorsal view. Scale = 1 mm.

Structure: elongate oval. Body with moderately dense, moderately long upright hairs, longest on base of scutellum and medially on abdominal venter. The following with short, semidecumbent hairs: head below and at base dorsally; callus; scutellar base; prosternum; propleuron centrally; meso- and metapleura anteriorly; and all margins of pronotal sterna. Head scarcely declivent, somewhat conical in appearance when viewed from above; buccula low, tapering gently posteriorly, reaching or nearly reaching prosternum. Antennal segment I surpassing anteclypeus by slightly less than half its length. Labial segment I surpassing prosternal margin by about half its length, extending about ⅔ distance from anterior prosternal margin to procoxa, II reaching middle of mesocoxa, III reaching abdominal sternum IV, IV reaching or almost reaching abdominal sternum V. Pronotum coarsely punctate before and slightly behind callus; callus and lateral margin moderately swollen. Scutellum with lateral margin basally almost same height as T-shaped carina, lower apically. Claval commissure about same length as scutellum. Prosternum and propleura coarsely punctate, deepest in front of and just behind center of pleuron, posterolateral area of pleuron nearly impunctate. Mesopleuron with a few very small shallow punctures. Metapleuron impunctate. Pygophore as in Figs. 73d, e; ventral projection of sides of dorsal opening slightly visible from above; lateral projection of dorsal opening slightly bifid, dorsal channel shallow. Clasper as in Figs. 73a-c; caudolateral lobe subconical; hook blunt but well developed. Aedeagus as in Fig. 73f, g; ejaculatory reservoir as in Figs. 73h, i. Ovipositor as in Figs. 74b-d; first valvula just reaching apex of first ramus. Spermatheca as in Fig. 74a; pigmented section basal of sperm pump long.

Measurements: 6♂, 2♀. Length ♂ 13.5 (13.2-14.0), ♀ 13.7, 14.6; abdominal width ♂ 4.2 (4.0-4.4), ♀ 4.5, 4.8; head length ♂ 1.63 (1.36-2.23), ♀ 1.52, 2.35; width across eyes ♂ 2.08 (1.55-2.28), ♀ 1.70, 2.16; pronotal length ♂ 2.27 (2.12-2.40), ♀ 2.16, 2.44; pronotal width ♂ 3.83 (3.74-4.00), ♀ 4.00, 4.02; scutellar length ♂ 1.62 (1.56-1.73), ♀ 1.68, 1.75; scutellar width ♂ 1.99 (1.80-2.12), ♀ 2.28, 2.33; length antennal segments I ♂ 1.01 (.94-1.04), ♀ 1.08, II ♂2.71 (2.64-2.78), ♀ 2.71, III ♂ 1.99 (1.90-2.04), ♀ 1.95, IV ♂ 2.46 (2.18-2.57); length labial segments I ♂ 2.24 (2.11-2.32), ♀ 2.29, 2.48, II ♂ 2.36 (2.28-2.48), ♀ 2.66, 2.68, III ♂ 2.82 (2.72-2.90), ♀ 3.10, 3.44, IV ♂ 1.65 (1.56-1.74), ♀ 1.74, 1.78.

Comments.—The color pattern of *P. leucurus* is very distinctive. Some in-

dividuals of *Oncopeltus* spp. have a somewhat similar color pattern but are easily separated from this species by their tumid scutellum and posteriorly directed pronotal projections.

Pyrrhobaphus leucurus is a widespread species occurring from India to the Pacific region. The only Australian specimens known to me are a series of five males and one female collected near Airlie, Queensland, on October 10th, 1957, and presently in the University of Queensland collection. I have taken nymphs of this species on the seed capsules of *Ipomoea* sp. in the New Hebrides.

Melanerythrus Stål

Lygaeus s.g. *melanerythrus* Stål, 1868:75-76.

Melanerythrus China, 1930:115; Slater, 1964*a*:118.

Brachylygaeus Gross, 1965:24-26. syn. nov.

Type-species *Lygaeus mactans* Stål, 1867, monobasic.

Diagnosis.—Scutellum swollen; no lateral scutellar foveae; posterior pronotal margin straight or slightly concave; ostiolar peritreme tumid but not greatly produced; spermatheca long, irregularly coiled, tubular, pigmented and wider apically.

Gross (1965) erected the genus *Brachylygaeus* to contain *Lygaeus mutilatus* Erichson. While noting the similarity to *Melanerythrus* he felt that the reduction in length of the hemelytra of that species, its lack of black medial markings on the corium, and its lack of a white area at the base of the hemelytral membrane were sufficiently different to warrant the erection of a new genus.

In the course of this study I have seen specimens of *Melanerythrus biguttatus* lacking black corial markings and specimens of *Melanerythrus mactans* with these markings reduced. The submacropterous specimen of *B. mutilatus* referred to by Gross (1965) does have a small white mark at the basal angle of the membrane (this almost obscured by grease). Though to date no micropterous specimens of either *M. biguttatus* or *M. mactans* have been discovered, the former shows considerable variation in development of the forewing. Some specimens showing more reduction than the submacropterous specimen of *B. mutilatus*. Based on these observations and on the similarity of both male and female genitalia of the three species I have no hesitation in treating them as congeneric.

As presently understood *Melanerythrus* contains five species, all with an entirely or primarily Australian distribution. It may easily be separated from all other Australian Lygaeinae by being micropterous, or if macropterous by the combination of tumid scutellum and straight posterior pronotal margin. (*Oncopeltus,* the only other Australian genus with a tumid scutellum, has the posterior margin of the pronotum strikingly produced posteriorly to either side of the scutellum.) The shape of the head when viewed from above is also very distinctive due to a slight swelling anterior to the eyes. This gives it a rather elongate, parallel-sided appearance and a "pop-eyed" look due to the outline of the eyes not blending into that of the rest of the head.

On the basis of the genitalia *Melanerythrus* appears more closely related to *Spilostethus* than to other Australian Lygaeine genera. The general appearance of both male and female external genitalia of the two genera being quite similar.

Redescription.—Color: Orange or red and black in varying combinations.

Structure: Size medium to large,

body length 6.2 to 10.7; macropterous, submacropterous, or micropterous; entire body granulate, dull; antenna, labium, and legs shiny. Head moderately to strongly declivent; wider than long; convex; swollen anterior to eye, appearing parallel-sided; ocelli much closer to eyes than to each other; buccula prominent, almost reaching anterior prosternal margin, convex, tapering gently posteriorly; eye slightly pedunculate, adjacent to anterior pronotal angle. Antennal segment I surpassing anteclypeus by slightly less than half its length, II longest, IV slightly shorter than II. Labium not surpassing metacoxa; segment I slightly surpassing anterior prosternal margin. Pronotum rounded laterally, slightly convex; punctations present or not; median carina indicated behind callus; callus swollen, sometimes strongly, reaching lateral margin; callar impression slightly oblique, either unbranched or with short branch near lateral end; shallow depression behind callus reaching or almost reaching lateral margin; anterior margin concave, most strongly in micropter; posterior margin straight in macropter and submacropter, concave in micropter; lateral margin of micropter subparallel, strongly constricted behind callus, of macropter and submacropter subparallel anteriorly, angled strongly mesad from base to callus; shallow impression at posterior margin either side of scutellum. Scutellum tumid, slightly foveate at anterolateral angle; either extremely convex (micropterous species) or nearly flat; apex acute. Hemelytra of micropters with clavus and corium undifferentiated; membrane reduced to short flap, not or slightly extending posterior to scutellar apex; macropters and submacropters with costal corial margin slightly convex, veins slightly raised. Prosternum impunctate; sometimes coarsely rugose; anterior margin slightly raised. Meso- and metasterna impuncate, coxal margins raised. Propleuron impunctate centrally, punctate or coarsely rugose anteriorly and posteriorly. Mesopleuron impunctate except sparsely, shallowly near posterior margin. Metapleuron impunctate; ostiolar peritreme well developed; posterior margin nearly straight, directed posteroventrally, subparallel to posterior mesopleural margin; convex bump near anterolateral angle; posterolateral angle rounded. Legs unarmed. Abdominal sternum II almost completely visible laterally; III to VII with anterolateral scent gland openings; VII of male concave posteriorly; VII of female cleft almost to base, sloping gently from lateral margin to cleft. Abdominal dorsum with medio- and paratergites fused; inner laterotergites indistinctly separated from medio- and paratergites II to VI; all tergites fused on VII. Pygophore with median projection well developed, ridge on each side separated from projection by narrow channel; dorsal opening with depressed shelf laterally opposite terga. Clasper with large, thumb-like caudolateral lobe; blade subtriangular in cross section basally, flattened apically; shank excavated mesally. Aedeagus with raised phallothecal process curved and with undercut projection; phallothecal surface with dorsal median carina, depressed between carina and phallothecal process; conjunctiva robust, with subapical dorsal lobe on each side; low lobe over ejaculatory reservoir; vesica robust, lobeless; ring sclerite almost complete, lightly sclerotized; ejaculatory reservoir well developed, lacking basal projection; gonoporal process visibly covered by membrane almost to apex, secondary gonopore with short, acute process.

Ovipositor with connecting membrane of first valve cleft and with a well defined median sclerite; first valvula not reaching apex of connecting membrane; connecting membrane of second valve deeply cleft medially, moderately pigmented; second valvula rounded apically. Spermatheca moderately long, irregularly coiled, swollen apically, about apical ⅔ pigmented; sperm pump little differentiated from basal tube, basal to pigmented area.

Key to the Species of Melanerythrus Stål

1. Calli red or orange; micropterous; pronotum coarsely rugose except calli, nearly as wide across calli as across base 2
1′. Calli black; micropterous or not; pronotum punctate or nearly smooth, never coarsely rugose, much wider across base than across calli 3
2. Boldly marked with orange and black . . . . . *uptoni,* sp. nov.
2′. Nearly completely dull red . . . . . *ignitus,* sp. nov.
3. Pronotum black and orange; macropterous . . . . . *mactans* Stål
3′. Pronotum black; macropterous or not 4
4. Pronotum coarsely punctate; never micropterous . . . . . *biguttatus* (Fabricius)
4′. Pronotum at most indistinctly punctate; usually micropterous. . . . . *mutilatus* (Erichson)

Melanerythrus biguttatus
(Fabricius 1775)

Figures 33; 35; 75e, f; 76i-l; 77c, d, m; 78c, i; 79c, d.

Cimex biguttatus Fabricius, 1775:720.
Cimex australis Gmelin, 1790:2173.
Lygaeus biguttatus Fabricius, 1794:158.
Lygaeus divisus Walker, 1872:62-63.
Melanerythrus biguttatus Distant, 1901*a*: 536; Slater, 1964*a*:118-119.

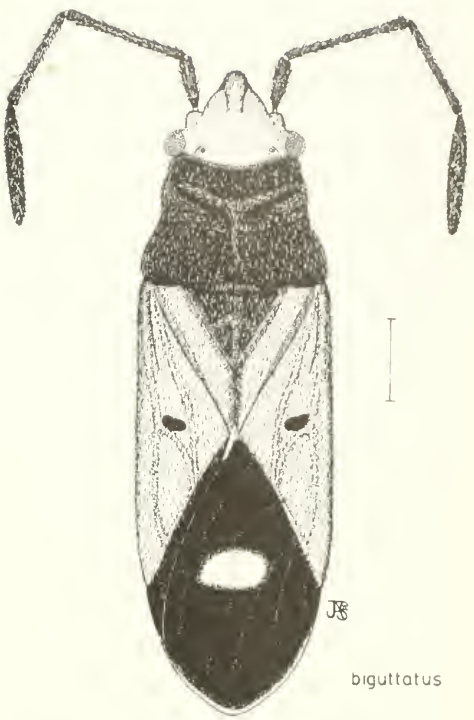


FIG. 33. *Melanerythrus biguttatus,* (Fabricius), dorsal view. Scale = 1 mm.

Type.—Type ♂, no label, in BMNH (Banks collection). The type locality given by Fabricius as "Nova Hollandia".

Redescription.—Color: Orange. The following black: head laterally anterior of antenniferous tubercle; head ventrally; head basally posterior of eye and ocellus; apical half anteclypeus; pronotum; scutellum; rounded discal corial macula; thoracic sterna; thoracic pleura; anterolateral angles of abdominal sterna III to VII; sterna VI and VII medially; genital segments; and tergum VII medially. The following dark brown to black; antenna; labium; and legs. Eye brown, Ocellus red. Hemelytral membrane brown except white basal angle, discal spot, and apical margin.

Structure: Head sharply declivent, hairs dorsally and laterally short, decli-

vent, densest laterally, hairs ventrally longer, upright, sparse. Labial segment I slightly surpassing anterior prosternal margin, II reaching procoxa, III reaching mesocoxa, IV slightly surpassing metasternum. Pronotum coarsely punctate except callus; callus slightly oblique, callar impression subsinuate, unbranched; median carina obsolete anterior to callus and at posterior margin, well defined medially; hairs moderately long, semidecumbent, sparse, densest on callus. Scutellum slightly convex, median carina well defined, shallow transverse striations laterally; hairs moderately long, semiupright, moderately dense. Clavus parallel sided; hairs semiupright, moderately long and dense. Corium with slightly convex costal margin; apex usually reaching tergum VI, occasionally reaching only tergum V; hairs semiupright, moderately long and dense, absent on and immediately surrounding discal macula. Hemelytral membrane of macropter reaching or nearly reaching tip of abdomen; of submacropter reaching tergum VII or occasionally VI; basal cell absent in extreme submacropter. Prosternum with very shallow punctures; hairs very thin, moderately long, semiupright, sparse. Meso- and metasterna impunctate; hairs very thin, moderately long and dense, semiupright. Propleuron sparsely, coarsely punctate anteriorly and posteriorly; hairs moderately long and dense, semiupright, very thin. Mesopleuron with a few coarse punctures posteriorly; hairs thin, moderately long and dense, semidecumbent anteriorly, semiupright posteriorly. Metapleuron with low anterolateral bump; hairs as on mesopleuron. Abdominal sterna with long semidecumbent hairs, dense medially, gradually shorter and sparser laterally. Pygophore as in Figs. 75e, f. Clasper as in Figs. 76j-l; blade less flattened distally than other *Melanerythrus* species. Aedeagus generally as in *M. mactans* (Fig. 77i); phallotheca as in Figs. 76i, 77m, dorsum less sculptured than in other members of the genus; ejaculatory reservoir as in Figs. 77c, d. Ovipositor as in Figs. 78c, 79c, d. Spermatheca as in Fig. 78i.

Measurements: Length ♂ 6.9 (6.4-7.4), ♀ 7.6 (6.2-8.2); abdominal width ♂ 2.1 (1.9-2.3), ♀ 2.4 (2.0-2.6); head length ♂ .91 (.73-1.04), ♀ 1.11 (.98-1.25); width across eyes ♂ 1.56 (1.48-1.61), ♀ 1.66 (1.54-1.80); pronotal length ♂ 1.40 (1.29-1.50), ♀ 1.50 (1.34-1.63); pronotal width ♂ 2.04 (1.93-2.19), ♀ 2.32 (1.98-2.60); scutellar length ♂ .91 (.78-1.03), ♀ .98 (.79-1.08); scutellar width ♂ 1.10 (.98-1.23), ♀ 1.20 (.95-1.38); length antennal segments I ♂ .57 (.53-.61), ♀ .58 (.54-.61), II ♂ 1.33 (1.21-1.46), ♀ 1.34 (1.24-1.46), III ♂ 1.10 (1.02-1.21), ♀ 1.11 (1.03-1.20), IV ♂ 1.26 (1.14-1.40), ♀ 1.22 (1.10-1.38); length labial segments I ♂ .74 (.66-.83), ♀ .81 (.75-.86), II ♂ .80 (.73-.88), ♀ .89 (.84-.95), III ♂ .92 (.85-.99), ♀ 1.02 (.95-1.05), IV ♂ .92 (.89-.99), ♀ .97 (.93-1.05).

Comments.—The combination of a completely black, punctate pronotum, and orange corium with a small black discal macula and a large white discal macula on the hemelytral membrane distinguish *M. biguttatus* from all other Australian Lygaeinae. In some specimens from Western Australia and Timor the black corial macula is lacking or much reduced and the hemelytral membrane appears mottled with white due to irregular expansion of the white areas.

In Australia *M. biguttatus* is apparently restricted to tropical and subtropical coastal regions (Fig. 35). I have also examined specimens from Timor and Papua New Guinea. Adults

have been collected on mangroves, maize seedlings, "Graminae", and *Oenothera drummondii*. I believe that only the latter two should be considered host records.

Melanerythrus ignitus, *sp. nov.*

Figures 35; 75a, b; 76e-h; 77e, f, i, l; 78e, h; 79a, b.

Types.—Holotype ♀, "Herald Bight, Shark Bay, W.A., 5-VII-1943, C. P. Whitley" in AM. Paratypes: 9♂, 3♀, "Shark Bay, W.A., 28-VII-1964, L. E. Koch"; 1♀, "Waroona Station, W.A., 28-VII-1974, L E. Koch"; 1♀, "Marillana Station, 8-VIII-1958, A. M. Douglas" all in WAM.

Description.—Color: Dull red. The following sometimes black: tergal scent gland scars; anterolateral angles of abdominal sterna and outer laterotergites III to VII; abdominal terga VI and VII medially; abdominal sternum VII; and genital segments. Antenna and tarsi often apically infuscated. Labium red to reddish brown basally darkening to nearly black apically. Eye brown. Ocellus red. Hemelytral membrane brown at base, whitish apically. One specimen with black spot at anterior margin of propleuron.

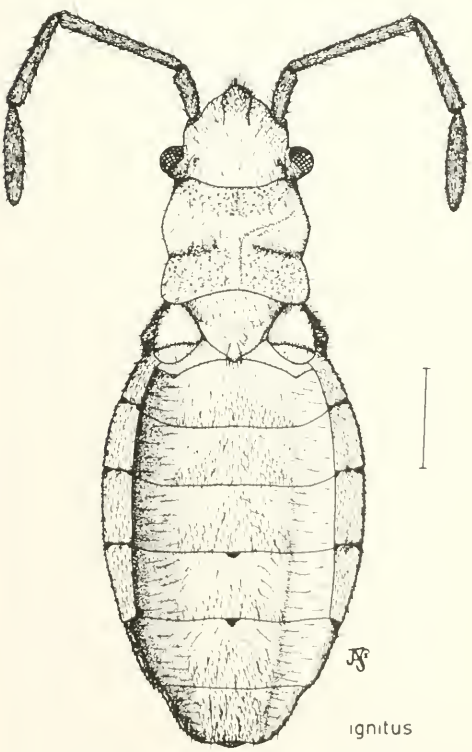


Fig. 34. *Melanerythrus ignitus*, sp. nov., dorsal view. Scale = 1 mm.

Structure: Micropterous. Head strongly declivent; hairs short, sparse on vertex, long upright hairs interspersed dorsally, hairs semidecumbent ventrally. Labial segment I slightly surpassing anterior pronotal margin, II reaching procoxa, III reaching mesocoxa, IV reaching posterior metasternal margin. Pronotum subquadrate; coarsely rugose before and behind callus; median carina well developed posteriorly, obsolete anteriorly, callus transverse, strongly swollen, occupies about half pronotal length laterally; callar impression oblique, sinuate, unbranched; sparse, interspersed short decumbent and long upright hairs. Scutellum strongly convex; lateral fovea well developed giving carinate appearance apically; lateral margin convex apically; apex bluntly angulate; interspersed moderately long, dense decumbent and long, sparse upright hairs. Clavus and corium fused, subtriangular; posterior margin rounded apically; apical margin straight; hairs as on scutellum, very sparse on disc. Hemelytral membrane reduced, subtriangular, rounded apically, reaching or slightly surpassing scutellar apex, not or barely reaching abdominal tergum II. Prosternum very coarsely punctate. Propleuron very coarsely punctate except center, nearly as long as combined meso- and metapleura; hairs moderately long, semidecumbent, sparse. Meso- and metasterna

with dense, moderately long, upright hairs. Mesopleuron coarsely punctate posteriorly; hairs moderately long and dense, semiupright. Metapleuron with well developed anterolateral bump; hairs as on mesopleuron but denser. Abdominal sterna with dense, decumbent, moderately long hairs sparsely interspersed with long semiupright hairs, both types densest medially and posteriorly. Abdominal terga with sparsely but evenly distributed long semiupright hairs interspersed medially and on outer laterotergites with dense shorter decumbent hairs. Pygophore as in Figs. 75a, b. Clasper as in Figs. 76f-h. Aedeagus similar to *M. mactans* (Fig. 77i); ejaculatory reservoir as in Figs. 77e, f; phallotheca as in Figs. 76e, 77l. Ovipositor as in Figs. 78e, 79a, b. Spermatheca as in Fig. 78h.

Measurements: 9♂, 6♀. Length ♂ 6.2 (5.9-6.5). ♀ 7.0 (6.6-7.4); abdominal width ♂ 2.3 (2.0-2.5), ♀ 2.8 (2.5-3.1); head length ♂ 1.03 (.90-1.13), ♀ 1.04 (.85-1.19); width across eyes ♂ 1.46 (1.43-1.51), ♀ 1.56 (1.50-1.60); pronotal length ♂ 1.07 (1.04-1.15), ♀ 1.19 (1.09-1.29); pronotal width ♂ 1.52 (1.50-1.56), ♀ 1.76 (1.63-1.85); scutellar length ♂ .75 (.70-.83), ♀ .88 (.74-1.08); scutellar width ♂ .96 (.85-1.03), ♀ 1.17 (1.05-1.20); length antennal segments I ♂ .55 (.53-.60), ♀ .59 (.58-.60), II ♂ 1.22 (1.18-1.27), ♀ 1.39 (1.33-1.44), III ♂ .98 (.93-1.03), ♀ 1.08 (1.03-1.14), IV ♂ 1.10 (1.07-1.15), ♀ 1.13 (1.08-1.15); length labial segments I ♂ .85 (.83-.89), ♀ .92 (.89-.98), II ♂ .84 (.81-.85), ♀ .90 (.88-.93), III ♂ .74 (.69-.78), ♀ .79 (.78-.81), IV ♂ .69 (.65-.75), ♀ .74 (.70-.78).

Measurements holotype ♀. Length 6.8; abdominal width 2.6; head length 1.03; width across eyes 1.58; pronotal length 1.14; pronotal width 1.63; scutellar length .75; scutellar width 1.05; length antennal segments I .58, II 1.41, III 1.09, IV 1.15; length labial segments I .93, II-IV obscured by card mount.

Comments.—*Melanerythrus ignitus* is named for both its color and the climate of its type locality. The species appears to be restricted to western Australia (Fig. 35).

The combination of microptery and virtual lack of black markings separates this species from all other Australian Lygaeinae. It is somewhat similar in appearance to members of the African genus *Apterola* Mulsant and Rey but the head and pronotum appear rather longer than in that genus and the calli are much more swollen. I have not seen the genitalia of *Apterola*.

Melanerythrus ignitus and *M. uptoni* show very pronounced structural differences from the rest of the genus, even more so than do micropterous specimens of *M. mutilatus*. However these differences are consistent with reduction in wing length. The male and female genitalia are typical of the genus.

Melanerythrus mactans *(Stål 1867)*

Figures 35; 75g, h; 76m-p; 77g-j; 78b; 79g, h.

Lygaeus mactans Stål, 1867:162.

Lygaeus (Melanerythrus) mactans Stål, 1868:76.

Lygaeus ruficeps Walker, 1872:63.

Stalagmostethus mactans Kirkaldy, 1908: 355.

Stalagmostethus melanesicus Kirkaldy, 1909:31.

Spilostethus mactans Bergroth, 1916:33.

Melanerythrus mactans China, 1930:115; Slater, 1964*a*:119; Slater, 1978:857.

Types.—Lectotype ♀, "Austral occid." "Thorey." in Stockholm. Paralectotypes: 1♀, "Austral. boreal."; 1♀, "Ins. Fidschi." in Stockholm.

Redescription.—Color: Bright orange. The following black: head around eye and ocellus; sometimes tip of anteclypeus; buccula; pronotum except area of humeral angle; scutellum; clavus distally; transverse medial corial fascia widened costally to include subapical third of costal margin; thoracic pleura and sterna; anterolateral angles of abdominal sterna III to VI; sternum VII; genital segments; tergum VII; and sometimes sterna IV to VI medially. The following dark brown to black: antennal segments I distally, II, III, usually IV; labial segments; and legs. Eye brown. Ocellus red. Hemelytral membrane brown except white basal angle, discal spot, and margins.

Structure: Head moderately declivent; hairs short, sparse, decumbent dorsally, denser laterally and ventrally. Labial segment I surpassing anterior prosternal margin by about 1/5 its length, II reaching posterior margin of procoxa, III reaching posterior margin of mesocoxa, IV reaching posterior margin of metasternum. Pronotum shallowly punctate anterior to and immediately behind callus; median carina obsolete except immediately behind callus; callus almost transverse, impression often with short branch near lateral end; hairs short, decumbent, sparse posteriorly, denser anteriorly. Scutellum slightly convex; without median carina; hairs short, decumbent, sparse except anterolaterally. Clavus parallel-sided; hairs short, dense, decumbent. Corium with moderately convex costal margin; hairs short, decumbent, sparse except narrow costal border slightly widened at black fascia. Hemelytral membrane reaching or surpassing apex of abdomen. Prosternum impunctate; with shallow, poorly defined, transverse striations; hairs short, sparse, decumbent. Meso- and metasterna with dense, moderately long, upright hairs. Propleuron shallowly striate; a few coarse, elongate punctures; hairs short, decumbent, denser posteriorly. Mesopleuron with hairs short, decumbent, denser posteriorly. Metapleuron with poorly developed anterolateral bump; hairs short, decumbent, denser anteriorly. Abdominal venter with dense, thicker, semidecumbent hairs interspersed with longer more upright hairs. Pygophore as in Figs. 75g, h. Clasper as in Figs. 76n-p. Aedeagus as in Fig. 77i; phallotheca as in Figs. 76m, 77j; ejaculatory reservoir as in Figs. 77g, h. Ovipositor as in Figs. 78b, 79g, h. Spermatheca as in Fig. 78g.

Measurements: Length ♂ 9.1 (7.3-9.6), ♀ 9.6 (8.3-10.7); abdominal width ♂ 2.9 (2.8-3.1), ♀ 3.1 (2.7-3.4); head length ♂ .97 (.85-1.20), ♀ 1.00 (.80-1.20); width across eyes ♂ 1.89 (1.73-2.03), ♀ 1.92 (1.78-2.08); pronotal length ♂ 1.73 (1.40-1.95), ♀ 1.82 (1.63-2.06); pronotal width ♂ 2.57 (2.04-2.78), ♀ 1.46 (1.33-1.75); length antennal segments I ♂ .65 (.54-.69), ♀ .64 (.58-.68), II ♂ 1.58 (1.41-1.68), ♀ 1.53 (1.45-1.61), III ♂ 1.25 (1.00-1.36), ♀ 1.17 (1.07-1.28), IV ♂ 1.39 (1.18-1.51), ♀ 1.35 (1.23-1.53); length labial segments I ♂ 1.09 (.95-1.16), ♀ 1.14 (1.04-1.28), II ♂ 1.03 (.98-1.10), ♀ 1.08 (1.05-1.13), III ♂ .83 (.75-.90), ♀ .86 (.83-.90), IV ♂ .76 (.66-.83), ♀ .77 (.73-.81).

Comments.—*Melanerythrus mactans* is easily recognized by its black pronotum with broad orange lateral margins of the posterior lobe, black corial fascia, and large white macula of the hemelytral membrane. Some species of *Oncopeltus* approach this appearance but their dark pronotal areas are at most piceous and they have pronotal projections extending posteriorly on either side of the scutellum.

On clean, degreased, specimens the anterior lobe of the pronotum, the anterolateral scutellar angles, and most of the thoracic venter are pruinose.

Two females examined were slightly submacropterous, the hemelytral membrane reaching only the posterior margin of abdominal tergum VII. An apparently fully mature female from the Northern Territory, in the collection of the University of Queensland, has yellow, rather than orange, and brown, rather than black, markings.

Melanerythrus mactans has the widest distribution of any member of the genus, occurring almost throughout Australia. It has been reported from Fiji and I have seen specimens from Timor. The Australian distribution (Fig. 35) indicates that the species prefers arid conditions. Adults and nymphs were collected in Western Australia under *Solanum* sp. and under *Solanum lucani* by Mr. R. I. Storey. Additional records which probably do not constitute true food plants are strawberries, pecan nut trees, and "in soil around cherry trees".

Melanerythrus mutilatus
(Erichson 1842)

Figures 35; 75c, d; 76a-d; 77a, b, k; 78a, f; 79e, f.

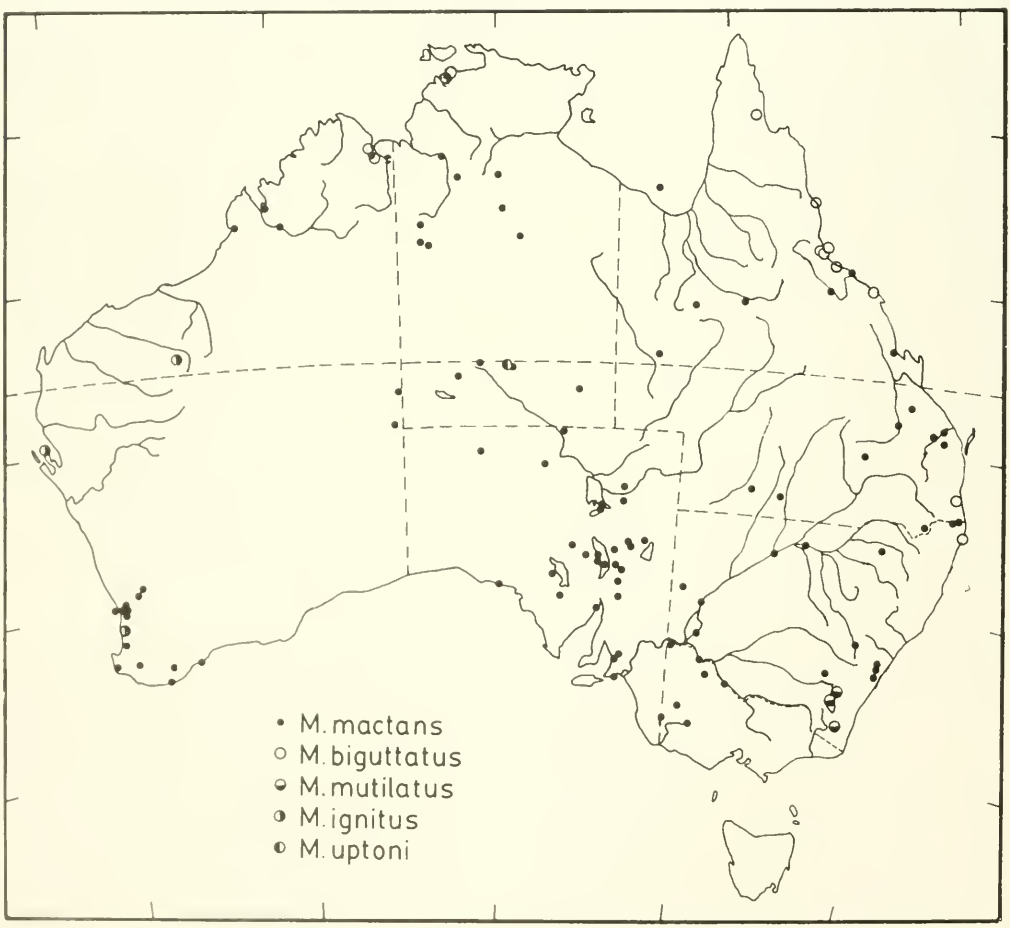


FIG. 35. Distribution of *Melanerythrus mactans* (Stål), *M. biguttatus* (Fabricius), *M. mutilatus* (Erichson), *M. ignitus*, sp. nov., and *M. uptoni*, sp. nov. in Australia.

Lygaeus mutilatus Erichson, 1842:279; Slater, 1964*a*:116.

Brachylygaeus mutilatus Gross, 1965:24-26.

Type.—Type lost (Woodward, 1962). Erichson lists Tasmania as the type locality.

Redescription.—Color: Orangey red. The following black: base of head, widest laterally to include base of eye and ocellus; head laterally and ventrally anterior to antenniferous tubercle; anteclypeus except base; pronotum; scutellum; posterior and apical hemelytral margins; thoracic sterna and pleura; broad longitudinal vitta laterally on abdominal sterna IV to VI; abdominal sternum VII; genital segments; abdominal terga I, VI, and VII; abdominal terga II to V medially; antenna; labium; and legs. Eye brown. Ocellus red. Hemelytral membrane of micropter brown basally, white apically; of submacropter brown with white mark at basal angle, subdiscal macula, and narrow apical border.

Structure: Head moderately declivent; hairs moderately long, sparse, upright dorsally, semidecumbent ventrally. Labial segment I reaching anterior prosternal margin, II reaching procoxa, III reaching mesocoxa, IV reaching middle of metasternum. Pronotum usually impunctate, occasionally with faint punctures anterior to callus; median carina well defined on posterior lobe, faintly indicated on anterior lobe; hairs short, dense, decumbent, interspersed with some longer, upright hairs. Scutellum quite convex; lateral fovea well developed distally giving appearance of broad median carina; faint transverse striations laterally; hairs as on pronotum. Clavus and corium of micropter fused, truncate apically, reaching posterior margin of abdominal tergum I, veins absent, hairs as on pronotum, denser on margins; of submacropter distinct, clavus slightly narrowed distally, costal corial margin slightly convex, veins slightly raised, hairs of clavus and of corial margins short, decumbent, moderately dense, on disc and interspersed on clavus and margins of corium moderately long, upright hairs. Hemelytral membrane of micropter a small convex flap not surpassing apex of scutellum; of submacropter reaching posterior margin of abdominal tergum VII, venation reduced on one wing forming five cells on the other. Prosternum very shallowly punctate; anterior margin raised; hairs short, sparse, semiupright. Meso- and metasterna impunctate; hairs moderately long, dense, semiupright. Propleuron with shallow punctures anteriorly and posteriorly, impunctate centrally; hairs short, semidecumbent, sparsest anteriorly and posteriorly. Mesopleuron with scattered shallow punctures posteriorly, otherwise impunctate; hairs short, semidecumbent, moderately dense. Metapleuron with anterolateral bump moderately developed; hairs semidecumbent, dense anteriorly, sparse and slightly longer posteriorly. Abdominal sterna with interspersed short, decumbent and sparse longer upright hairs, denser medially and posteriorly on sternum VII. Abdominal terga with short sparse semiupright hairs, densest medially. Pygophore as in Figs. 75c, d. Clasper as in Figs. 76b-d. Aedeagus similar to *M. mactans* (Fig. 77i); phallotheca as in Figs. 76a, 77k; ejaculatory reservoir as in Figs. 77a, b. Ovipositor as in Figs. 78a, 79e, f. Spermatheca as in Fig. 78f.

Measurements: 8♂, 10♀. Length ♂ 8.3 (7.7-8.5), ♀ 8.5 (8.0-9.3); abdominal width ♂ 2.7 (2.5-2.8), ♀ 3.0 (2.5-3.4); head length ♂ 1.08 (.88-1.25), ♀ 1.06 (.95-1.20); width across eyes ♂

1.75 (1.68-1.80), ♀ 1.78 (1.71-1.88); pronotal length ♂ 1.60 (1.45-1.68), ♀ 1.58 (1.40-1.93); pronotal width ♂ 2.14 (1.93-2.28), ♀ 2.25 (1.85-2.73); scutellar length ♂ 1.14 (1.06-1.23), ♀ 1.22 (.95-1.48); scutellar width ♂ 1.25 (1.13-1.34), ♀ 1.34 (1.18-1.50); length antennal segments I ♂ .70 (.64-.74), ♀ .69 (.64-.74), II ♂ 1.55 (1.41-1.68), ♀ 1.54 (1.39-1.68), III ♂ 1.15 (1.06-1.23), ♀ 1.16 (1.08-1.23), IV ♂ 1.36 (1.25-1.50), ♀ 1.34 (1.28-1.44); length labial segments I ♂ 1.09 (1.00-1.18), ♀ 1.14 (1.05-1.20), II ♂ 1.04 (.98-1.13), ♀ 1.09 (1.03-1.13), III ♂ .86 (.83-.90), ♀ .93 (.85-.98), IV ♂ .78 (.75-.80), ♀ .79 (.78-.83).

Comments.—The completely black pronotum combined with microptery, or in the case of submacropters with a black apical corial margin, separate *Melanerythrus mutilatus* from all other Australian Lygaeinae. Gross (1965) provides figures of the dorsum.

Originally described from Tasmania, the locality data of known specimens indicate that this is an alpine or subalpine species. It is apparently restricted to southeastern Australia (Fig. 35). During the course of this study several males and females were taken on or under *Craspedia macrocephala* among snow gums near the summit of Mt. Gininni, ACT.

Melanerythrus uptoni, *sp. nov.*

Figures 35; 36; 78d, j.

Type.—Holotype ♀, "Standley Chasm, 43 km. W. by S. of Alice Springs, N.T., 11-X-1972, M. Upton." in ANIC.

Description.—Color: Orange. The following dark brown to black: head around eye and ocellus; tip of anteclypeus; buccula; anterior and posterior pronotal margins; scutellum; abdominal terga I and VII completely,

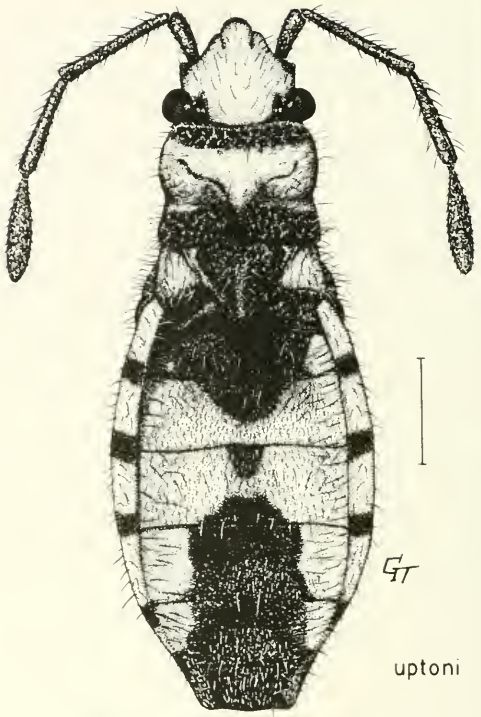


FIG. 36. *Melanerythrus uptoni,* sp. nov., dorsal view. Scale = 1 mm.

II, V, and VI medially, III anteromedially, and IV antero- and posteromedially; outer laterotergites II to VI anteriorly and narrowly at posterior margin; thoracic sterna; thoracic pleura except propleuron lateromedially; abdominal sternum II anteriorly, VII completely, III to VI at anterolateral angle, and broad diffuse longitudinal vitta medially from posterior part of II to VI, narrowed anteriorly; and legs. Eye, antenna, and labium brown. Ocellus orange. Hemelytral membrane brown with faint whitish border.

Structure: Very similar to *M. ignitus,* sp. nov., differing in: pronotum anterior to callus less differentiated from callus; scutellum extending posterad of abdominal tergum I, less convex laterally with apex more acutely angulate; hemelytral membrane less rounded,

not approaching scutellar apex or posterior margin of tergum I; punctures of pronotum, thoracic pleura, and thoracic sterna shallower and slightly better defined; apex of second valvula (Fig. 78d) shorter, less flattened and with less concave ventral margin; spermatheca as in Fig. 78j; decumbent hairs shorter and much less dense except on abdomen; long hairs on pronotum, scutellum, and hemelytra relatively longer.

Measurements: Holotype ♀. Length 6.4; abdominal width 2.4; head length .83; width across eyes 1.50; pronotal length 1.10; pronotal width 1.63; scutellar length .85; scutellar width 1.08; length antennal segments I .51, II 1.21, III .96, IV 1.10; length labial segments I .88, II .83, III .78, IV .71.

Comments. — *Melanerythrus uptoni* is named for the collector of the only known specimen, M. E. Upton. The micropterous form and orange pronotum with blackish anterior and posterior margins distinguishes this species from all other Australian Lygaeinae. As mentioned above it is very similar structurally to *M. ignitus,* sp. nov. It is possible that study of a series of specimens will show that the structural features are variable enough and/or that the male genitalia are similar enough to justify synonymizing the two species.

Melanotelus Reuter

Melanotelus Reuter, 1885:200, 202; Scudder, 1968:156; Slater and Sperry, 1973:156-157.

Lygaeosoma Bergroth, 1918:57-58 (part); Slater, 1964*a*:64-65 (part), 1964*b*:49 (part).

Type-species *Melanotelus argillaceus* Reuter, 1885 (fixed by Distant, 1904).

Diagnosis.—Base of head black; pronotum tumid, calli scarcely protruding; posterolateral metapleural angle slightly produced posteriorly; para- and mediotergites III to VI separate; tergal apodemes on paratergites III and IV, on mediotergites V and VI; and very long, apically curved, upright hairs over whole dorsum.

The genus *Melanotelus* was erected by Reuter (1885) for a group of medium sized lygaeines previously included in the omnibus genus *Lygaeus* Fabricius. Bergroth (1918) synonymized it with *Lygaeosoma* Spinola on the ground that the character separating the two genera (angulate vs. truncate posterior metapleural margins) was too variable to warrant a generic division. Scudder (1968) removed *Melanotelus* from synonymy, stating only that he found it "... a distinct genus." Slater and Sperry (1973) concurred, adding "... the species we have examined have a habitus very distinct from 'typical' *Lygaeosoma* species." Examination of the male and female genitalia and of the abdominal dorsum has provided excellent evidence of their separate generic status. In *Lygaeosoma* there is a lateral sclerite on either side of the conjunctiva, the gonoporal process is short and thick, the spermatheca is short with a round pigmented apical lobe, and the tergal apodemes of abdominal segments III to VI are all on the paratergites. In *Melanotelus* there are no conjunctival sclerites, the gonoporal process is very long and thin, the spermatheca is elongate and slightly swollen apically, and the tergal apodemes of abdominal segments V and VI are on the mediotergites.

Little is known of the biology of members of the genus. Slater and Sperry (1973) surmise that they feed on a variety of mature seeds and state that *M. villosulus* (Stål) was easily reared on sunflower seeds in the laboratory. Scudder's (1968) report of two female *M. bipunctatus* (Dallas) taken during

aerial trapping over the ocean about three kilometers off the coast of India indicates that species may have good powers of dispersal. The only biological information available for Australian species is a note on a specimen collected at Kambah, ACT, by G. F. Hill stating that it was found in an *Iridomyrmex* (Formicidae) nest.

Redescription.—Color: Head dorsally black or dark brown; black macula at humeral angle of pronotum; black macula at posterolateral angle of metapleuron (sometimes also of pro- and mesopleura); scent gland orifice pallid, sometimes infuscated basally; antenna, labium, and legs dark brown to black; hemelytral membrane black except white basal and apical margins; abdominal segment VII and genital segments dark brown to black.

Structure: Subovoid, widest across middle of abdomen; head, thorax, and hemelytra granulate, dull; abdominal venter, antenna, labium, and legs shiny; pronotum, scutellum, clavus, corium, and dorsum of head sparsely covered with long, upright hairs. Head declivent, convex; ocelli much closer to eyes than to each other; buccula prominent; lateral and ventral hairs short, decumbent. Labium not extending

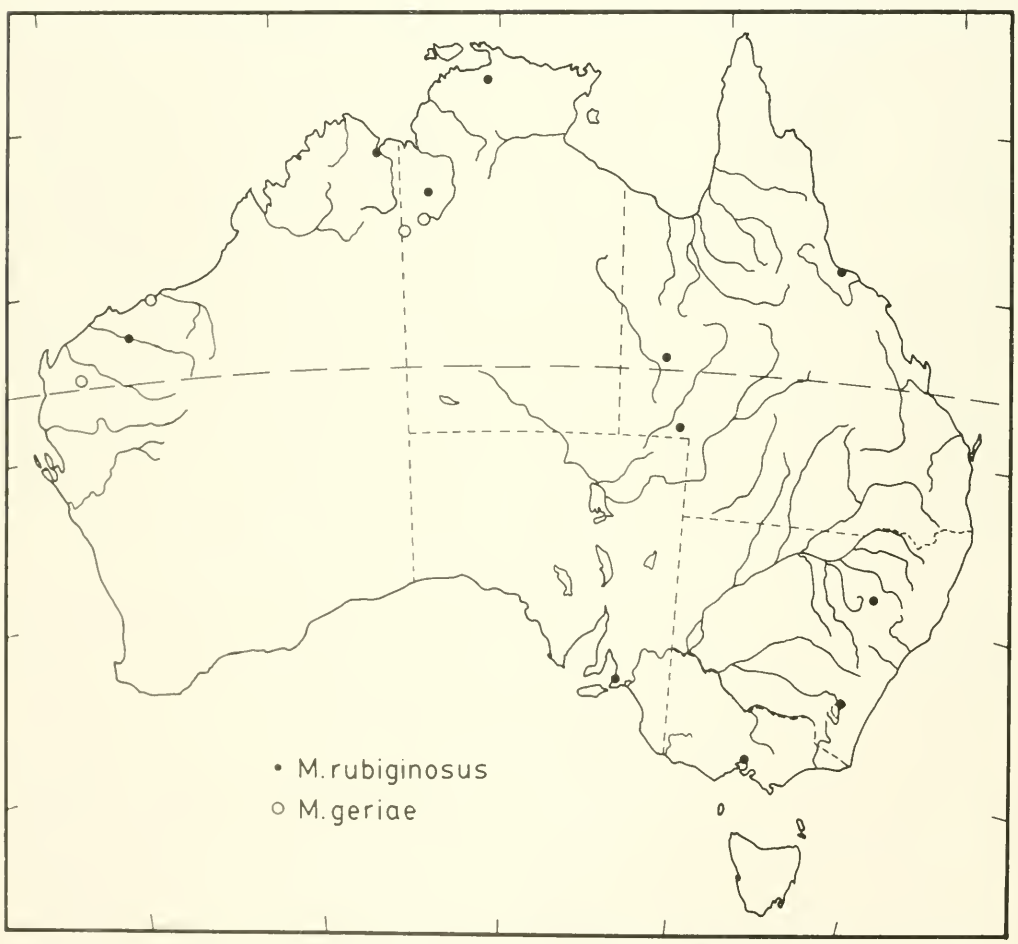


FIG. 37 Distribution of *Melanotelus rubiginosus* (Walker) and *M. geriae*, sp. nov.

caudad of metacoxa (except in *M. argillaceus* Reuter where from the description it reaches abdominal segment III); segment I thickest, II slightly thinner, III and IV thinner than II and about equally thick. Pronotum moderately tumid, subquadrate, widest basally, coarsely punctate; callus slightly raised; callar impression slightly oblique, sinuate, unbranched; shallow interrupted impression at posterior margin near humeral angle; median carina obsolete, barely indicated immediately behind callus; anterior margin concave; lateral margin straight or slightly sinuate; posterior margin subsinuate, slightly convex. Scutellum wider than long; median carina T-shaped; lateral fovea in angle of T very deep. Corium with slightly convex costal margin; veins slightly raised. Prosternum with anterior margin extending anterad of posterior margin of eye; anterior margin raised; punctate; hairs sparse, short, and upright. Meso- and metasterna impunctate; hairs dense, short, and upright. Mesopleuron raised anteriorly; coarsely punctate; hairs longer and denser than on propleuron, densest posteriorly. Metapleuron raised anteriorly; coarsely punctate at least in part; hairs upright, longer than on mesopleuron, densest anteriorly; ostiolar peritreme well developed; posterior margin concave, directed anteroventrally; posterolateral angle produced, somewhat rounded. Abdominal sternum II almost covered by metapleuron; female sternum VI slightly shorter medially than laterally; posterior margin of male sternum VII truncate; female sternum VII cleft almost to base; sterna without dorsolateral gland openings; all segments hirsute. Abdominal dorsum with paratergites III to VI separate, apparently fused with laterotergites on female VII, with mediotergite on male VII; posterior margin of female VII truncate, of male VII convex. Pygophore subcircular in cross section; median hypandrial projection well developed; projection of lateral wall of dorsal opening just anterior to insertion of clasper. Clasper with well developed caudolateral lobe; blade broad, flattened; shank deeply excavated, well developed overhanging projection. Aedeagus with phallotheca lightly pigmented; phallothecal process curved, projecting slightly laterad, sculptured apically; conjunctiva short, robust, and subapical dorsolateral lobe on each side; ejaculatory reservoir complete, without basal projection, covered by low membranous lobe; vesica basally robust, twisted, lobed; ring sclerite complete, heavily pigmented, short, narrowed distally; vesica apically short, coiled, striate and lightly pigmented towards apex; gonoporal process long, coiled, visibly covered by membrane only at extreme base; secondary gonopore simple, without apical process. Ovipositor with first valvula not reaching apex of connecting membrane; connecting membrane of first valve deeply cleft medially, a median sclerite surrounding cleft. Spermatheca elongate, tubular, loosely coiled, pigmented distally, slightly swollen subapically; sperm pump at base of pigmented part, elongate, swollen.

Key to the Australian Species of Melanotelus

1. Clavus and corium with interspersed short, fine, decumbent and long, stout, upright hairs; base color brown to brownish red . . . . . *rubiginosus* (Walker)

1'. Clavus and corium with only long, stout, upright hairs; base color brilliant scarlet . . . . . *geriae*, sp. nov.

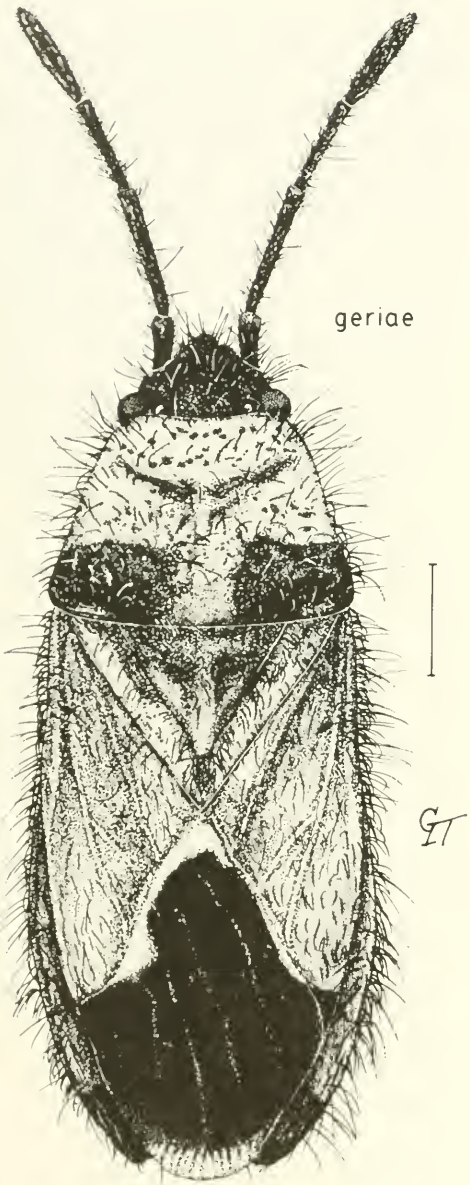


FIG. 38. *Melanotelus geriae*, sp. nov., dorsal view. Scale = 1 mm.

Melanotelus geriae, *sp. nov.*

Figures 37; 38; 80d-g, j, k, o; 81c-e.

Types.—Holotype ♂, "Northern Territory, 39 km SW of Wave Hill Homestead, 17.39 S, 130.52 E, 13-VIII-1969, M. Mendum." in ANIC. Paratypes: 1♂, same data as holotype, in ANIC; 1♀, 7 km S of Inverway Homestead, 17.55 S, 129.38 E, 25-VI-1969, M. Mendum" in ANIC; 1♂, "Western Australia, Port Headland (airport), 19-II-1973, E. M. Exley" in UQ; 4♂, 4♀, "Western Australia, Uaroo Station, 25-VI-1964, L. E. Koch" in WAM.

Description.—Color: Bright scarlet. The following black; head dorsally; subrectangular macula at hemeral angle of pronotum; rounded macula at posterolateral metapleural angle; abdominal segment VII; genital segments; hemelytral membrane except white basal and apical margins. Head ventrally brownish red, buccula infuscated. Eye brown. Antenna, labium, and legs dark brown to black. Metapleural scent gland orifice scarlet, sometimes infuscated basally.

Structure: Head moderately declivent; buccula prominent, tapered gradually caudad. Antennal segment I surpassing anteclypeus by about half its length. Labial segment I extending caudal of buccula by about half its length, slightly surpassing anterior prosternal margin, II reaching procoxa, III reaching mesocoxa, IV reaching metacoxa. Pronotum with callus impunctate. Clavus with sparse, short, decumbent hairs only at posterior margin. Corium with hairs densest basally, shortest apically on costal margin. Hemelytral membrane reaching tip of abdomen. Prosternum extending anteriorly to about midline of eye. Abdomen ventrally with interspersed medium to long decumbent and upright hairs. Pygophore similar to *M. rubiginosus* (Figs. 80p, q), projection of lateral margin of dorsal opening as in Fig. 80o. Clasper as in Figs. 80d-f. Aedeagus as in Fig. 80q; phallothecal process as in Fig. 80i, heavily sclerotized; ejaculatory reservoir as in

Figs. 80j, k. Ovipositor as in Figs. 81c, d. Spermatheca as in Fig. 81e.

Measurements: 7♂, 5♀. Length ♂ 7.1 (6.4-7.6), ♀ 7.6 (6.6-8.2); abdominal width ♂ 3.0 (2.7-3.3), ♀ 3.2 (2.7-3.5); head length ♂ .54 (.42-.60), ♀ .68 (.60-.75); width across eyes ♂ 1.60 (1.50-1.68), ♀ 1.66 (1.58-1.70); pronotal length ♂ 1.66 (1.55-1.85), ♀ 1.74 (1.62-1.85); pronotal width ♂ 2.64 (2.40-3.00), ♀ 2.61 (2.48-2.85); scutellar length ♂ 1.28 (1.12-1.38), ♀ 1.22 (1.15-1.30); scutellar width ♂ 1.50 (1.22-1.75), ♀ 1.45 (1.30-1.62); length antennal segments I ♂ .53 (.42-.68), ♀ .52 (.42-.60), II ♂ 1.18 (.95-1.30), ♀ 1.17 (.88-1.30), III ♂ .89 (.70-1.18), ♀ .87 (.70-.95), IV ♂ 1.04 (.95-1.15), ♀ 1.04 (.90-1.10); length labial segments I ♂ .84 (.65-.95), ♀ .88 (.68-.95), II ♂ .78 (.65-.88), ♀ .86 (.68-.95), III ♂ .91 (.70-1.05), ♀ .99 (.70-1.12), IV ♂ .64 (.55-.70), ♀ .67 (.62-.70).

Measurements holotype ♂. Length 6.6; abdominal width 2.7; head length .42; width across eyes 1.52; pronotal length 1.55; pronotal width 2.48; scutellar length 1.20; scutellar width 1.40; length antennal segments I .45, II .95, III .72, IV .95; length labial segments I .65, II .65, III .70, IV .55.

Comments.—This most strikingly colored lygaeid is named for Geraldine Slater.

Melanotelus geriae is easily separated from other members of the genus by its large size and striking coloration. It is somewhat similar to *M. bipunctatus* (Dallas) but is much more brightly colored, lacks short decumbent hairs on the clavus and corium, and the prosternum is not produced as far forward as the anterior margin of the eyes.

This species is apparently restricted to the arid regions of northern and western Australia (Fig. 37). The specimens examined from Western Australia average slightly larger than those from Northern Territory.

Melanotelus rubiginosus
(Walker 1872)

Figures 37; 39; 80a-c, h, l-n, p, q; 81a, b, f.

Rhyparochromus rubiginosus Walker, 1872:110.

Melanotelus rubiginosus Distant, 1901*b*: 464, 465, 509.

Lygaeosoma bipunctata Slater, 1964*a*:66 (part).

Melaneotelus bipunctatus Slater and Sperry, 1973:157 (part).

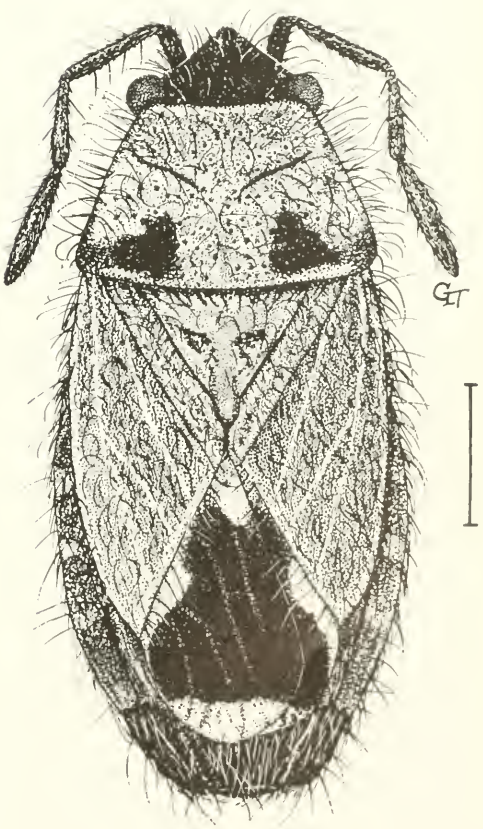


Fig. 39. *Melanotelus rubiginosus* (Walker), dorsal view. Scale = 1 mm.

Type.—Type ♀, "Victoria." in BMNH.

Redescription.—Color: Dark chocolate to light reddish brown; scutellum and anterior half of pronotum often darker than clavus, corium, and posterior half of pronotum; veins often lighter than rest of corium. The following black: subtriangular macula at humeral angle of pronotum; rounded macula at posterolateral angle of pro-, meta-, and sometimes mesopleura (that of metapleuron usually largest); hemelytral membrane except white basal and apical margins. The following dark brown to black: head; antenna; labium; legs; outer laterotergites III to VI anteriorly; abdominal segment VII; and genital segments. The following pallid: buccula; acetabulae; anterior prosternal margin; posterior propleural margin; posterior and lateral metapleural margins; and ostiolar peritreme. Eye brown. Ocellus red. Abdominal sterna II to VI reddish brown.

Structure: Hairs except of clavus and corium similar to but denser and finer than those of *M. geriae*. Head sharply declivent; buccula prominent, sharply declivent posteriorly. Antennal segment I surpassing anteclypeus by about half its length. Labial segment I extending posterior of buccula by 1/4 to 1/3 its length, II almost reaching procoxa, III almost reaching mesocoxa, IV reaching posterior margin of mesocoxa. Pronotum with sinuate lateral margin; entire surface including callus coarsely punctate. Clavus and corium with fine, short, decumbent hairs on entire surface. Hemelytral membrane surpassing apex of abdomen in macropter, reaching abdominal tergum VII in submacropter. Prosternum extending anteriorly to middle of eye. Pygophore as in Figs. 80p, q; projection from lateral margin of dorsal opening as in Fig. 80n. Clasper as in Figs. 80a-c. Aedeagus similar to that of *M. geriae* (Fig. 80g); phallothecal process as in Fig. 80h; ejaculatory reservoir as in Figs. 80l, m. Ovipositor as in Figs. 81a, b. Spermatheca as in Fig. 81f.

Measurements: Length ♂ 5.1 (4.8-5.7), ♀ 5.8 (5.4-6.3); abdominal width ♂ 2.2 (2.1-2.4), ♀ 2.6 (2.4-3.1); head length ♂ .54 (.44-.64), ♀ .56 (.48-.80); width across eyes ♂ 1.31 (1.24-1.40), ♀ 1.44 (1.36-1.52); pronotal length ♂ 1.23 (1.12-1.40), ♀ 1.37 (1.28-1.48); pronotal width ♂ 1.91 (1.76-2.08), ♀ 2.28 (2.08-2.44); scutellar length ♂ .91 (.86-1.00), ♀ 1.12 (.98-1.30); scutellar width ♂ 1.07 (.94-1.24), ♀ 1.30 (1.12-1.44); length antennal segments I ♂ .36 (.34-.44), ♀ .37 (.36-.40), II ♂ .77 (.68-.82), ♀ .80 (.74-.94), III ♂ .60 (.52-.68), ♀ .61 (.54-.76), IV ♂ .94 (.84-1.00), ♀ .94 (.88-1.02); length labial segments I ♂ .57 (.52-.64), ♀ .64 (.60-.68), II ♂ .48 (.42-.50), ♀ .54 (.50-.58), III ♂ .52 (.50-.54), ♀ .57 (.54-.64), IV ♂ .50 (.48-.54), ♀ .55 (.48-.60).

Comments.—Walker (1872) described *Melanotelus rubiginosus* in the genus *Rhyparochromus* from a single Victorian specimen presented to the BMNH by W. W. Saunders. Distant (1901*b*) noted that Walker's description did not agree with the type specimen and suggested that ". . . Walker intended this for his type and inadvertently described something else." He also suggested that *M. rubiginosus* might be a variety of *M. bipunctatus* (Dallas) though in listing Walker's species at the end of his article he retained it as a valid species. Slater (1964*a*) listed *M. rubriginosus* (sic) (Walker) as a synonym of *M. bipunctatus* (Dallas), at that time considered to belong to the genus *Lygaeosoma* Spinola.

Comparison of the type specimen

with Walker's original description reveals that they agree except in the base color. The type is light brown while the description says it is black. As most of the other species described at the same time in *Rhyparochromus* are black it seems likely that prior to the printing of his catalogue Walker or someone else altered the description without referring to the type specimen.

The dull brown coloration combined with the generic characters distinguish *M. rubiginosus* from other Australian Lygaeinae. *Melanotelus bipunctatus* from the Oriental region is very similar in general appearance but differs in: larger (length 6.9); labial segment I extending posterior of anterior prosternal margin by half its length; anterior prosternal margin extending anteriorly to level with front of eye; upright hairs shorter and denser on hemelytra; hairs on abdominal venter of medium length, very dense, and all apparently decumbent; dull red in color with scutellum, clavus, and corium darker than anterior part of pronotum; black pronotal macula rounded; and black pleural maculae subequal.

Melanotelus rubiginosus is very similar to *M. timorensis* Distant, known only from Timor, but differs in that antennal segments I and II and labial segments I and II are slightly shorter, the upright hairs of the dorsum are longer, coarser and less dense, and the black pronotal maculae extend further mesally and are less rounded. Additionally *M. timorensis* lacks fine semidecumbent hairs on the clavus and corium and the ground color is redder than the lightest examples of *M. rubiginosus*.

This species is widespread in Australia (Fig. 37), apparently preferring dry inland areas.

Spilostethus Stål

Lygaeus s.g. *Spilostethus* Stål, 1868:72.
Lygaeodon Puton, 1869:139.
Spilostethus Reuter, 1912:19 (part); Slater, 1964*a*:193, 1964*b*:28-29; Hamid and Meher, 1973*a*:35, 37, 1973*b*: 188-192.

Type-species *Climex militaris* Fabricius, 1775 = *Cimex pandurus* Scopoli, 1763 (fixed by Slater, 1964*b*).

Diagnosis.—Ostiolar peritreme obsolete; lateral pronotal margin swollen, presenting "rolled" appearance; phallothecal process complexly sculptured; secondary gonopore surrounded by disc with stout, pointed secondary process; usually all male femora armed with series of short spines.

Spilostethus was erected by Stål in 1868 as a subgenus of the omnibus genus *Lygaeus* Fabricius which at that time contained most species now comprising the subfamily Lygaeinae. Subsequent authors have treated it as a subgenus or junior synonym of *Lygaeus* or as a separate genus. Most members of the genus are large and brightly colored, greatly resembling members of *Lygaeus,* sensu stricto, in general appearance. Hamid and Meher (1973*a*) attribute 33 species to the genus, all from the eastern hemisphere. The greatest number of species in any one region is 18 in the Ethiopean region.

These are the only Australian lygaeines with an obsolete ostiolar peritreme and almost the only ones with armed femora. (*Thunbergia* species have a single subapical spine on the forefemur of both sexes.) Three species occur in Australia though a fourth, *S. pandurus* var. *elegans,* is listed in the literature as occurring there. Old specimens of this species bearing the label information "N.T." were examined. This variety is native to Africa and I do not believe

it likely to occur in Australia, the "N.T." possibly referring to North Transvaal. It is very distinctive, having the disc of the posterior pronotal lobe yellow, and the hemelytral membrane usually white.

Of the three Australian species one *(S. hospes)* is widespread in the Oriental region and the other two are endemic. The endemic species appear more closely related to each other than to *S. hospes* based on general shape and genitalic similarities. These two species have basal projections on the ejaculatory reservoir which may correspond to the "anvil-like" structure reported by Slater (1964*b*) for the *S. rivularis* group in South Africa.

Redescription.—Color: Boldly patterned in orange and black.

Structure: Body rather broad, nearly parallel-sided, finely granulate giving dull appearance. Antenna, labium, and legs shiny. Hairs short, decumbent, slightly longer and more dense on hemelytra, longer and more upright on venter of head and thoracic sterna. Head wider than long, moderately declivent, moderately convex; ocelli much closer to eyes than to each other; buccula prominent, tapering posteriorly, not reaching anterior prosternal margin. Antennal segment I surpassing anteclypeus by about half its length. Labial segment I longest, surpassing anterior prosternal margin; IV not surpassing posterior metasternal margin; I thickest, II slightly thinner, III and IV thinnest. Pronotum wider than long, nearly flat dorsally, punctate anterior of and immediately behind callus; callus and lateral margin slightly swollen, the latter laterally as well as dorsally; callar impression sinuate, a short branch at medial end, lateral end sometimes bifid; anterior margin slightly raised, concave; median carina faintly indicated; shallow oblique impression at posterior margin lateral of scutellum. Scutellum slightly wider than long; acuminate; T-shaped median carina present; lateral fovea deep, with transverse striations. Claval commissure about 3/4 length of scutellum. Corial veins prominent; costal margin straight in basal half, slightly convex in apical half. Hemelytral membrane reaching or slightly surpassing apex of abdomen. Prosternum punctate; anterior margin slightly raised. Meso- and metasterna impunctate; posterior margins raised. Propleuron punctate anteriorly and posteriorly; impunctate central part raised; anterior margin raised, most raised dorsally. Mesopleuron with scattered punctures. Metapleuron impunctate; posterior margin convex, directed dorsoventrally; posterolateral angle not produced; ostiolar peritreme obsolete, a channel with margins scarcely raised above pleural surface; slit or area of weakness at dorsal margin about 1/5 to 2/5 distance from anterior margin, curving ventrad posteriorly (this often difficult to see without clearing). Femora of male with two rows short, stout spines (except unarmed in *S. pacificus* (Boisduval)); of female unarmed. Abdominal sterna III to VII with dorsolateral gland openings; II not covered by metapleuron; female VII cleft about 1/2 distance to base, posterior margin nearly straight laterally, curving gently to median cleft; male VII slightly concave laterally and slightly convex medially. Abdominal terga with fused para- and mediotergites; inner and outer laterotergites II to VI distinct, VII fused with para- and mediotergites VII; posterior margin of female tergum VII produced to rear laterally, straight medially; posterior margin of male tergum VII slightly concave. Pygophore with well developed median projection;

lateral margin of dorsal opening with recessed "shelf." Clasper with well developed thumblike caudolateral lobe; blade narrow, flattened distally; shank deeply excavated laterally. Aedeagus with heavily pigmented phallotheca; phallothecal process variously sculptured; conjunctiva short, with single low medial lobe, membrane apparently attached basal to distal margin of phallotheca; vesica basally twisted, lobeless; ring sclerite complete, simple, heavily sclerotized; vesica apically lobeless, striate near ring sclerite; lightly pigmented; ejaculatory reservoir complete, with or without basal projection; gonoporal process rather short, membrane visible nearly to apex; secondary gonopore surrounded by flat disc surmounted by triangular process. Ovipositor somewhat reduced; first valvula reaching only about half distance to apex of connecting membrane; membrane connecting first valve cleft medially, produced narrowly distad on each side of cleft, broadly and deeply concave laterally before connection to valvula. Spermatheca thickened into irregular bulb apically; distal 1/3 to 2/3 pigmented; sperm pump just basal to pigmented area, containing a coiled, variously modified channel.

Key to the Australian Members of Spilostethus

1. Apical margin of corium orange or red; third labial segment longer than second . . . . . *hospes* (Fabricius)

1′. Apical margin of corium black; second labial segment longer than third 2

2. Black markings on disc of corium in form of oblique vittae; antennal segment IV longer than II; femora and tibiae of males armed with short spines . . . . . *decoratus* (Stål)

2′. Black spot or interrupted transverse fascia on disc of corium; antennal segment II subequal to

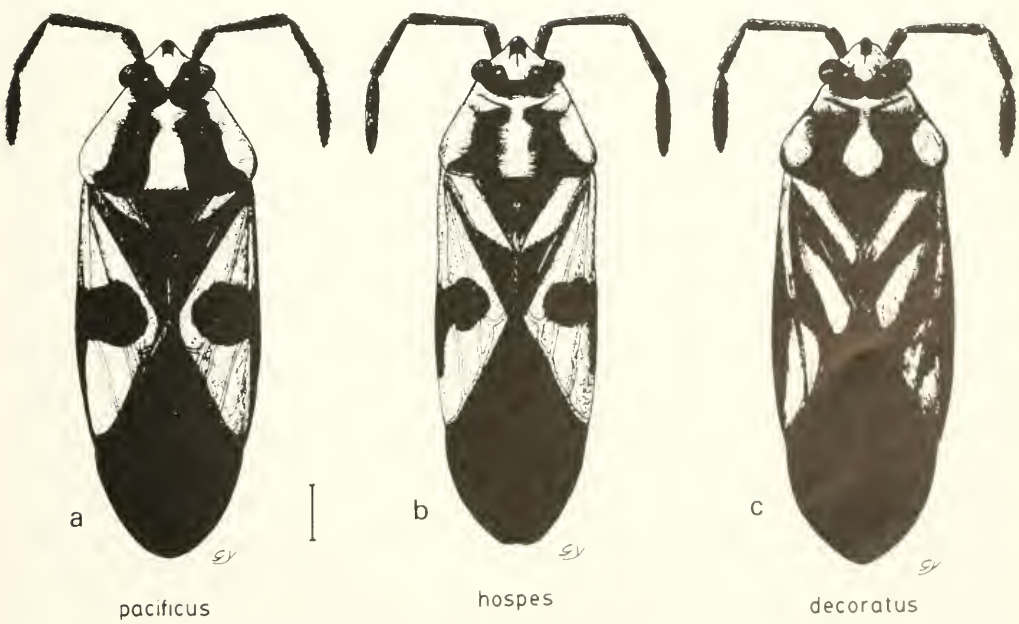


Fig. 40. *Spilostethus* spp., dorsal view: a. *S. pacificus* (Boisduval); b. *S. hospes* (Fabricius), c *S. decoratus* (Stal). Scale = 1 mm.

or longer than IV; femora and tibiae of males unarmed . . . . . *pacificus* (Boisduval)

Spilostethus decoratus *(Stål 1867)*

Figures 40c; 42; 82c, d, i, j, n; 83g-i, k; 84a, f, g.

Lygaeus decoratus Stål, 1867:162.

Lygaeus (Spilostethus) decoratus Stål, 1868: 75.

Spilostethus decoratus Slater, 1964*a*:196.

Type.—Type ♀, "Austral. boreal." "Thorey." in Stockholm.

Redescription.—Color: Bright orangey red. The following black: head around eye and ocellus; anteclypeus; pronotum anterior of callus, not reaching lateral margin; longitudinal macula behind each callus narrowly connected with lateral margin at callus and humeral angle; scutellum; apex and corial margin of clavus; corial margins except basal 2/5 of costal margin; narrow oblique vitta from center of costal corial margin to apical corial margin 1/3 distance from apex of clavus; narrow longitudinal vitta from base claval commissure to middle of oblique vitta; hemelytral membrane except narrow mark at basal angle; posterior half of prosternum; all meso- and metasternal margins; margins of propleuron except anterior and posterior half of lateral margins; dorsal, ventral, and posterior margins of meso- and metapleura; anterolateral angle of abdominal sternum III, anterior margins of IV to VI, VII except posterolateral angle; ventral half of male genital segments; anterior third of outer laterotergites III to VII; anterolateral angle and posterior margin mediotergite VII; antenna; labium; and legs. Buccula infuscated heavily basally, lightly apically. Eye and collar impression brown. Ocellus red. Mark at basal angle of hemelytral membrane brownish white.

Structure: Body robust. Buccula sharply tapered posteriorly. Labial segment I surpassing anterior prosternal margin by about 1/3 its length, II reaching posterior margin of procoxa, III reaching anterior margin of mesocoxa; IV reaching posterior margin of metacoxa. Pronotum shallowly, indistinctly to moderately punctate on posterior lobe; lateral margin including humerus moderately strongly swollen; posterior margin straight; lateral margin convex from humerus to immediately behind callus, concave from callus to anterolateral angle; hairs sparse posterior to callus. Clavus with oval subapical nearly hairless area. Corial hairs very sparse except at margins and along black vitta from base of claval suture to middle of apical margin. Pygophore as in Figs. 82c, d; apex of median projection undercut. Clasper as in Figs. 83g-i. Aedeagus similar to *S. hospes* (Fig. 83l); gonoporal process longer and thinner; ring sclerite shorter, barely complete; phallotheca as in Figs. 82n, 83k; ejaculatory reservoir as in Figs. 82i, j, basal projection present. Ovipositor as in Figs. 84f, g. Spermatheca as in Fig. 84a; flange at base of pigmented section.

Measurements: Length ♂ 11.0 (10.0-12.5), ♀ 11.9 (10.7-12.8); abdominal width ♂ 3.7 (3.3-4.2), ♀ 4.0 (3.6-4.3); head length ♂ .73 (.50-.96), ♀ .75 (.60-.88); width across eyes ♂ 1.97 (1.80-2.18), ♀ 2.08 (1.96-2.18); pronotal length ♂ 2.18 (1.74-2.45), ♀ 2.27 (1.70-2.60); pronotal width ♂ 3.53 (3.12-4.06); ♀ 3.83 (3.30-4.08); scutellar length ♂ 1.60 (1.44-1.72), ♀ 1.73 (1.65-1.80); scutellar width ♂ 1.87 (1.64-2.08), ♀ 2.05 (1.88-2.30); length antennal segments I ♂ .76 (.70-.88), ♀ .77 (.70-.87), II ♂ 1.72 (1.54-2.00), ♀ 1.72 (1.49-1.83), III ♂ 1.24 (1.12-1.40), ♀ 1.21 (1.06-1.28), IV ♂ 1.88 (1.70-2.16), ♀ 1.90 (1.80-2.10);

length labial segments I ♂ 1.16 (1.10-1.26), ♀ 1.21 (1.12-1.32), II ♂ 1.03 (1.00-1.08), ♀ 1.07 (1.00-1.14), III ♂ .87 (.82-.92), ♀ .91 (.90-.94), IV ♂ .73 (.68-.80), ♀ .71 (.65-.76).

Comments.—Spilostethus decoratus is easily separated from other members of the genus in Australia by the color pattern of the pronotum and hemelytra. A single specimen from Groote Eylandt has greatly reduced dorsal black areas and appears superficially similar to specimens of *S. hospes* with similar reductions. The apical corial margin of even this specimen is black thus separating it from *S. hospes*.

This species is restricted to northeastern Australia (Fig. 42) from the Queensland-New South Wales border to the nearer islands of the Torres Strait and Groote Eylandt in the west. Like other members of the genus it seems to prefer open woodland and grassland. Nothing is known of its food plant or biology.

Spilostethus hospes *(Fabricius 1794)*

Figures 40b; 41, 82a, b, g, h, m; 83a-c, l; 84c, h, i.

Lygaeus hospes Fabricius, 1794:150.
Cimex hospes. Turton, 1800:657.
Lygaeus affinis Wolff, 1802:110.
Lygaeus lanio Herrich-Schaeffer, 1843: 21.

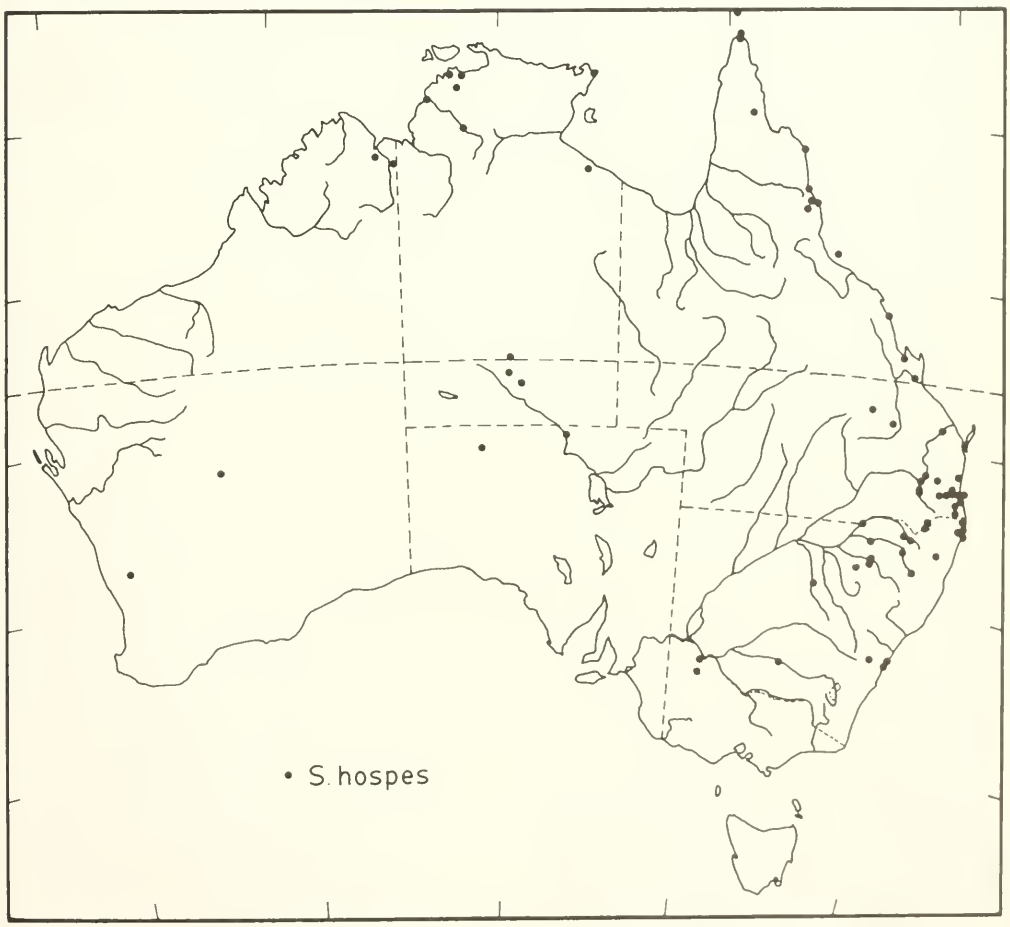


FIG. 41. Distribution of *Spilostethus hospes* (Fabricius) in Australia.

Lygaeus pacificus Dohrn (*nec* Boisduval), 1859:32; Hutton (*nec* Boisduval), 1874:170; Atkinson (*nec* Boisduval), 1882:171; Tryon (*nec* Boisduval), 1892:20.

Lygaeus squalidus Montrouzier, 1861:66.

Lygaeus (Spilostethus) hospes Stål, 1868: 75.

Lygaeus familiaris Stål (*nec* Fabricius), 1868:75.

Lygaeus (Spilostethus) familiaris Stål (*nec* Fabricius), 1870:609.

Lygaeus (Spilostethus) familiaris (var. *b.*) Stål (*nec* Fabricius), 1874:106.

Lygaeus hospes var. *celebensis* Breddin, 1901:17, 78.

Stalagmostethus familiaris var. *hospes* Kirkaldy, 1905:349.

Stalagmostethus hospes Breddin, 1907:42.

Spilostethus hospes Bergroth, 1914:356; Slater, 1964*a*:197-200 (part); Hamid and Meher, 1973*b*:188, 190-191.

Lygaeus familiaris Lever (*nec* Fabricius), 1937:329.

Lygaeus singularis Tillyard (*nec* Walker), 1926:144, 147, syn. nov.

In addition the following refer at least in part to this species.

Lygaeus pacificus Dallas, 1852:544; Walker, 1872:56, 57; Lethierry and Severin, 1894:144; Hutton, 1898: 173; Breddin, 1901:17; Distant, 1914:378.

Lygaeus (Spilostethus) pacificus Stål, 1874: 106; White, 1878:32.

Type.—Not seen. Type data "Habitat Tranquebariae. Dem. Smidt" in Kiel.

Redescription.—Color: Bright orangey red. The following black: head behind eye and around ocellus; anteclypeus and immediate surroundings; head below anterior to antenniferous tubercle; buccula; gular region; pronotum anterior of callus, reaching lateral margin; broad, slightly oblique longitudinal macula on each side of pronotum, slightly widened at posterior margin, slightly narrowed over callus, reaching anterior black area; scutellum except apex; clavus except scutellar margin, widest basally; posterior corial margin; subapical 3/5 of costal corial margin; rounded macula on corial disc, connected with base of claval suture by a vitta, broadly touching costal margin; hemelytral membrane except small whitish mark at basal angle; thoracic sterna; broad anterior, posterior, and ventral propleural margins; broad posterior, ventral, dorsal, and sometimes narrow anterior meso- and metapleural margins; anterolateral angles of abdominal sternum III; anterior margins of abdominal sterna IV to VII, occasionally interrupted laterally on IV and ventrally on IV to VI; abdominal sternum VII except posterolateral margin; male genital segments; female genital segments ventrally; anterior 1/3 of outer laterotergites III to VII; posterior margin of mediotergite VII; antenna; labium; and legs. Eye and ocellus brown.

Structure: Rather slender. Structure much as in generic description. Buccula tapering gradually posteriorly. Labial segment I surpassing anterior pronotal margin by about 1/3 its length, II reaching rear of procoxa, III reaching rear of mesocoxa, IV almost reaching rear of metacoxa. Pronotum not or indistinctly punctate posterior of callus; lateral margin moderately swollen; posterior margin slightly produced to rear lateral to scutellum; lateral margin convex from humerus to callus, nearly straight from callus to anterolateral angle. Clavus with oval subapical hairless area. Corium with discal macula nearly hairless; remainder moderately densely hirsute, densest along margins. Femora of male armed with short, stout spines antero- and posteroventrally, longest and most numerous api-

cally, shorter and often absent basally, number extremely variable, occasionally absent anteriorly or posteriorly but never completely absent. Pygophore as in Figs. 82a, b; concave posteriorly; median projection rather short and broad. Clasper as in Figs. 83a-c. Aedeagus as in Fig. 83l; ring sclerite complete, heavily sclerotized; phallotheca as in Figs. 82m, 83l; ejaculatory reservoir as in Figs. 82g, h, lacking basal projection. Ovipositor as in Figs. 84h, i. Spermatheca as in Fig. 84c.

Measurements: Length ♂ 10.7 (9.2-12.5), ♀ 11.1 (9.3-13.5); abdominal width ♂ 3.4 (3.0-4.2), ♀ 3.5 (2.9-4.3); head length ♂ .79 (.60-1.04), ♀ .82 (.64-1.12); width across eyes ♂ 1.85 (1.76-2.04), ♀ 1.92 (1.80-2.16); pronotal length ♂ 2.03 (1.64-2.32), ♀ 3.49 (3.04-4.32); pronotal width ♂ 3.19 (2.80-3.88), ♀ 3.49 (3.04-4.32); scutellar length ♂ 1.48 (1.28-1.70), ♀ 1.63 (1.42-2.00); scutellar width ♂ 1.69 (1.44-2.00), ♀ 1.85 (1.60-2.18); length antennal segments I ♂ .63 (.59-.70), ♀ .64 (.59-.80), II ♂ 1.69 (1.48-1.92), ♀ 1.70 (1.47-2.15), III ♂ 1.32 (1.11-1.56), ♀ 1.27 (1.11-1.60), IV ♂ 1.58 (1.34-1.77), ♀ 1.48 (1.32-1.74); length labial segments I ♂ 1.26 (1.16-1.40), ♀ 1.32 (1.20-1.54), II ♂ 1.21 (1.10-1.48), ♀ 1.21 (1.10-1.42), III ♂ 1.31 (1.10-1.86), ♀ 1.37 (1.18-1.55), IV ♂ .83 (.72-1.00), ♀.85 (.76-1.00).

Comments.—The comparatively slender body as well as the characters given in the key separate *S. hospes* from other Australian members of the genus.

Spilostethus hospes shows wide variation in the extent of the black dorsal areas. The color description above refers to a dark specimen. The longitudinal corial vitta and the black areas of the calli are usually the first to become reduced or disappear. In extreme cases only the base of the head behind the eyes, the tip of the anteclypeus, the pronotum anterior to the calli, the scutellum, the apex of the clavus, and small discal spots on the coria remain.

There may be a relation between climatic conditions and extent of the dark dorsal markings. In Australia northern and western specimens are usually lighter than those from southeastern Queensland and from New South Wales. The specimen from West Pakistan figured by Hamid and Meher (1973*b*, Fig. 2) resembles specimens from southeastern Australia while specimens from southern India resemble those from northern and western Australia. The darkest specimens examined were from mountainous areas of Papua, New Guinea, some of these having almost the entire coriacious part of the hemelytra so heavily infuscated that the black discal maculae are nearly obliterated.

The relative length of the third and fourth labial segments is quite variable (1.25:1-2.33:1). This ratio seems to be fairly consistent within populations and thus may indicate restricted gene flow between them. Analysis of that possibility is beyond the scope of this study.

The life history of *S. hospes* in China has been detailed by Hoffman (1932). He lists adults and nymphs taken on *Solanum nigrum* and adults feeding on *Physalis peruviana, Emila sonchifolia, Crotalaria saltiana,* and *Urena lobata.* The species has been reported on cotton (Ballard, 1927) and sandal (Chatterjee, 1937) though it is doubtful that these are really food plants. Bergroth's record of *S. pacificus* on *Wahlenbergia gracilis* at Ayer's Rock may in fact refer to this species. Mr. R. I. Storey has collected specimens on *Solanum lucani* and *Solanum lasiophylum* in Western Australia and I have collected specimens feeding on *Gomphocarpus* sp. (probably *physocarpa*), *Crassocephalum crepidoides,* and

Solanum sp. in southeastern Queensland. Malipatil (1979) provides brief notes on the life history and on food plants in Queensland.

The recorded range of *S. hospes* is from Iran and Japan in the north to New Zealand and Tasmania in the south. The New Zealand record, in the literature under the name *pacificus,* is either an error or refers to a chance occurrence. The specimen on which it is based, supposedly in the BMNH, could not be located for this study. The Tasmanian records almost certainly refer to the species now known as *S. pacificus* (Boisduval).

In Australia *S. hospes* ranges over most of the continent (Fig. 41), except the southernmost areas. I have also examined specimens from India, Thailand, Hong Kong, Ryukyu Islands, Philippine Islands, the Celebes, North Borneo, Ambon Island, Timor, New Guinea, New Britain, Guadalcanal, the New Hebrides, New Caledonia, and the Loyalty Islands.

Spilostethus pacificus
(Boisduval 1835)

Figures 40a; 42; 82e, f, k, l, o; 83d-f, j; 84b, d, e.

Lygaeus pacificus Boisduval, 1835:639-640.

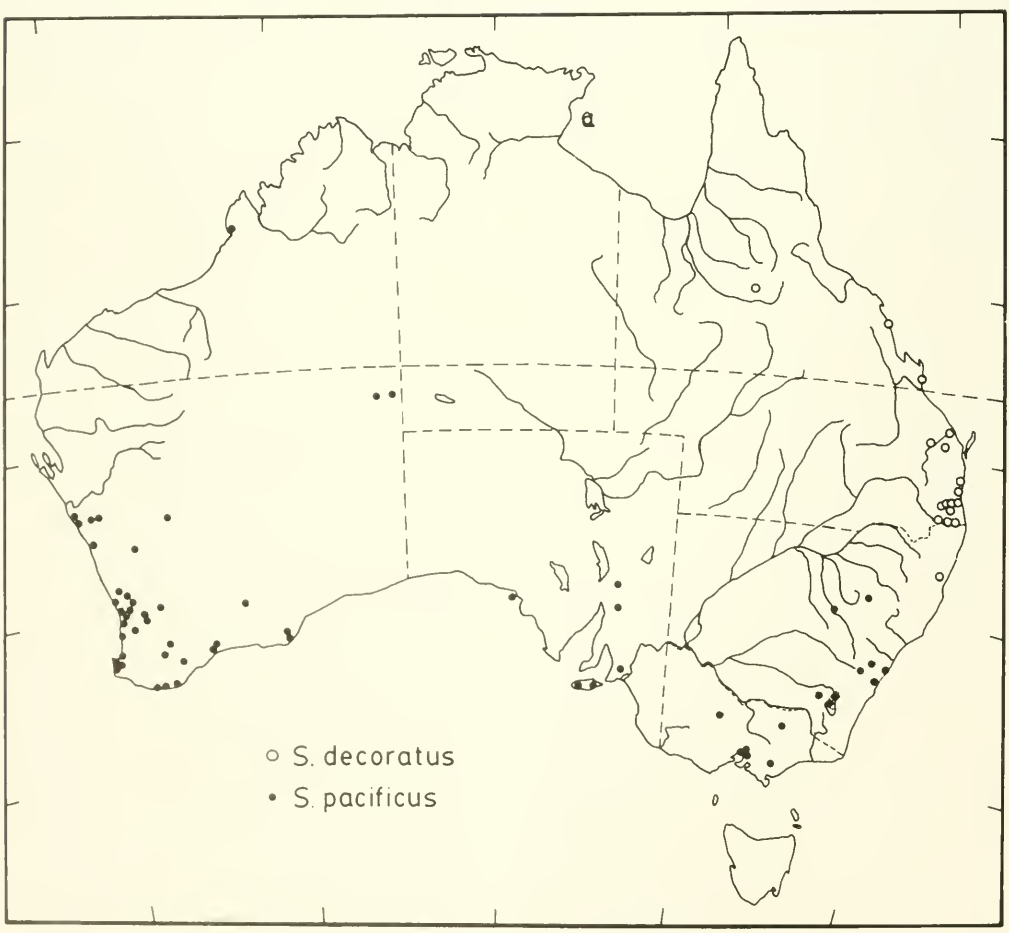


FIG. 42. Distribution of *Spilostethus decoratus* (Stål) and *S. pacificus* (Boisduval).

Lygaeus (Spilostethus) pacificus Stål, 1874: 106.

Lygaeus hospes Froggatt (*nec* Fabricius), 1901:17 (part). syn. nov.

Stalagmostethus pacificus Kirkaldy, 1909: 25.

Spilostethus pacificus Bergroth, 1916:33 (questionable).

Spilostethus hospes Barber, 1958:178, 179 (part); Slater, 1964*a*:197-200 (part).

Type.—Location of type unknown to me. The type locality "Western port, Pacific." (Boisduval, 1835: 640) appears to be Port Western, Victoria.

Redescription.—Color: Very similar to *S. hospes.* Black markings differ as follows: completely surrounding eyes and ocelli; restricted to anteclypeus; barely reaching anterolateral pronotal angle anterior of callus; macula narrower on posterior pronotal lobe; sometimes including scutellar apex; covering entire clavus except basal 1/4 adjacent to scutellum; covering apical margin and extreme apex of costal margin of corium; macula on disc of corium large, rounded, broadly reaching costal margin, not reaching claval margin; less broadly beyond discal macula on costal margin; more frequently interrupted and less extensive on abdominal sterna; completely covering female genital segments.

Structure: Body broad and robust. Buccula very rapidly tapered posteriorly. Labial segment I surpassing anterior prosternal margin by about 1/3 its length, II reaching rear of procoxa, III reaching mesocoxa, IV reaching metacoxa. Pronotum as in *S. decoratus* except lateral margin very strongly swollen. Clavus with oval subapical nearly hairless area. Corial hairs very sparse, denser at margins. Femora of both sexes unarmed. Pygophore as in Figs. 82e, f; rather truncate posteriorly; median projection considerably produced, very thin. Clasper as in Figs. 83d-f. Aedeagus similar to *S. hospes;* gonoporal process longer, thinner; ring sclerite shorter, barely complete; phallotheca as in Figs. 82o, 83j; ejaculatory reservoir as in Figs. 82k, l, lightly sclerotized basal projection present. Ovipositor as in Figs. 84d, e. Spermatheca as in Fig. 84b.

Measurements: Length ♂ 10.8 (10.0-12.2), ♀ 11.3 (10.3-12.3); abdominal width ♂ 4.0 (3.7-4.7), ♀ 4.1 (3.7-4.5); head length ♂ .76 (.60-.88), ♀ .85 (.70-1.04); width across eyes ♂ 1.94 (1.80-2.12), ♀ 2.03 (1.92-2.12); pronotal length ♂ 2.08 (1.82-2.40), ♀ 2.12 (1.76-2.45); pronotal width ♂ 3.74 (3.38-4.10), ♀3.95 (3.44-4.36); scutellar length ♂ 1.56 (1.40-1.92), ♀ 1.63 (1.40-1.84); scutellar width ♂ 2.02 (1.78-2.48), ♀ 2.07 (1.80-2.38); length antennal segments I ♂ .77 (.70-.83), ♀ .78 (.70-.84), II ♂ 1.63 (1.50-1.76), ♀ 1.63 (1.50-1.76), III ♂ 1.18 (1.03-1.30), ♀ 1.19 (1.05-1.30), IV ♂ 1.57 (1.40-1.78), ♀ 1.56 (1.40-1.65); length labial segments I ♂ 1.16 (1.10-1.28), ♀ 1.22 (1.10-1.44), II ♂ 1.06 (.95-1.20), ♀ 1.07 (.95-1.20), III ♂ .92 (.75-1.00), ♀ .93 (.85-1.04), IV ♂ .78 (.70-.84), ♀ .78 (.70-.84).

Comments.—*Spilostethus pacificus* is very similar in color to *S. hospes.* It is easily recognized by its broader, more robust appearance as well as the characters in the key.

This species was described by Boisduval from "Western port, Pacific." The original description could apply to several species in the genus and particularly to *S. hospes,* a widespread species in both Australia and surrounding areas. Mayr (1868) pointed out that males of *S. pacificus* lack the femoral spines characteristic of most of the genus. Barber (1958) synonymized it

with *S. hospes,* presumably basing this synonymy on the original description and on specimens identified as *S. pacificus* from areas other than southern Australia.

In the absence of the type specimen the possibility that what Boisduval described was a specimen of *S. hospes* cannot be entirely discounted. The illustration accompanying Boisduval's description is also somewhat ambiguous but the coloration appears to me closer to the present species than to *hospes.* If, as I believe, Port Western, Victoria, is the "Western port" referred to by Boisduval, then the species is most certainly not *hospes.* The range of *S. hospes* does not reach so far south in Australia and southern specimens of *S. hospes* have a distinct dark longitudinal vitta extending from the base of the claval suture to the discal macula of the corium. This marking does not appear in either the original description or accompanying figure of *S. pacificus.* I thus have no hesitation in removing *S. pacificus* Boisduval from synonymy with *S. hospes* (Fabricius) and in applying the name to the present species.

The range of *S. pacificus* is primarily southern, reaching farthest north in the west (Fig. 42). Nothing is known of its biology. The only food plant record is Bergroth's (1916) listing "Ayer's Rock, on *Wahlenbergia gracilis*" which may refer to *S. hospes.*

Oncopeltus Stål

Lygaeus s.g. *Oncopeltus* Stål, 1868:70, 75.

Oncopeltus Stål, 1872:40; Slater, 1964*a*: 162-163, 1964*b*:42; Slater and Sperry, 1973:160-161.

Transvaalia Distant, 1892:253.

Type-species *Cimex famelicus* Fabricius, 1781 (fixed by Distant, 1904).

Diagnosis.—Scutellum tumid; callus impressed below general level of pronotum; median pronotal carina well developed; posterior pronotal margin produced posteriorly laterad of scutellum; and spermatheca long, thin, intricately coiled, thickened basal sperm pump.

Oncopeltus occurs in both eastern and western hemispheres, most diversely in the tropics. At present the genus contains about 40 species in two subgenera, *Oncopeltus* sensu stricto with a worldwide distribution and *Erythrischius* which is restricted to the new world. The only lygaeine genera in Australia with which it might be confused are *Melanerythrus* and *Thunbergia.* The former often has a tumid scutellum but lacks posterior pronotal projections while the latter has such projections but does not have a tumid scutellum. In both genera the calli are at least moderately swollen.

Oncopeltus species often exhibit considerable within species variation in color and color pattern and very little between species structural variation. Assessing structural variation is made more difficult by the very soft (for a lygaeid) body which frequently shrinks and buckles when dried even if the specimen is fully mature. The male external genitalia are of some help in delimiting species but in some cases are very similar in what I consider to be distinct species. It is very possible that I have recognized more species than actually occur in Australia or have failed to recognize others. I believe that biological and/or cytological studies will be necessary finally to determine the limits of individual species.

Redescription.—Color: Variously patterned in orange, red, black, and purple.

Structure: Robust; soft bodied; impunctate; head dorsally and laterally,

abdominal venter medially, antenna, labium, and legs shiny, otherwise finely granulate, dull. Head moderately declivent; waxy area on vertex; hairs short, upright, moderately long dorsally, interspersed long stout and short fine hairs ventrally; eye adjacent to anterior pronotal angle; ocelli much closer to eyes than to each other; buccula low, slightly convex, sloping gently posteriorly, almost reaching anterior prosternal margin. Antennal segment I surpassing anteclypeus by about half its length; II or IV longest. Labium not or scarcely surpassing metacoxa; segment I thickest, II next thickest, III and IV about equally thick. Pronotum tumid, especially lateral margin; median carina well developed; anterior margin concave; posterior margin produced posteriorly as subtriangular flap lateral of scutellum, straight medially; lateral margin directed anteromedially, nearly straight, sometimes concave anteriorly, broadly rounded at humerus; callus recessed; callar impression slightly oblique, sinuate, unbranched; hairs long, stout, upright, and dense laterally, sparser and sometimes interspersed with short, fine decumbent hairs around callus, either long stout and upright or short fine and decumbent on posterior lobe. Scutellum tumid; longitudinal median carina distinct, most prominent apically; apex subacute, blunt; no lateral fovea or striations; hairs sparse, usually stout and upright. Hemelytron reaching or slightly surpassing tip of abdomen; basal half of costal margin of corium slightly concave, apical half slightly to strongly convex; veins prominent; hairs sparse, upright, variable in length and thickness. Thoracic sterna with posterior margins raised; hairs long, fine, and upright. Thoracic pleura with long, fine, upright hairs; posterior margin of metapleuron slightly sinuate, directed dorsoventrally; posterolateral angle of metapleuron not produced, broadly rounded. Abdominal sterna III to VII with dorsolateral gland openings; sternum II not covered by metapleuron; female sternum VII cleft to base, slightly concave laterally; male sternum VII slightly concave posteriorly; hairs sparse, fine semidecumbent, interspersed medially with long, stout, upright hairs. Abdominal dorsum with outer laterotergites clearly defined; inner laterotergites II to VI indistinctly separated from paratergites; paratergites III to VI indistinctly separated from mediotergites; laterotergites fused and distinctly separated from fused para- and mediotergites VII; mediotergites with large apodemes; paratergites with smaller but distinct apodemes. Pygophore rotund, truncate posteriorly; median projection well developed, rounded, subacute apically; short subacute projection lateral of median projection; tergum IX well defined. Clasper with well defined caudolateral lobe; blade circular in cross section at base, flattened and widened medially, narrowed apically, bluntly rounded to subacute; shank flattened but scarcely excavated, distinct but variously shaped projection and anterolateral ridge mesally; sometimes shelflike ridge beneath blade. Aedeagus with moderately sclerotized phallotheca, network of raised "wrinkles" laterally near phallothecal process; phallothecal process short, projecting slightly dorsally; conjunctiva short, robust, tubular, a large subapical dorsolateral lobe on each side, low dorsal lobe over ejaculatory reservoir; ejaculatory reservoir complete, short spinelike projection below distal connection with seminal duct; vesica basally robust, twisted, a single broad lateral lobe slightly beyond middle; ring

sclerite nearly complete, widest basally; vesica apically moderately robust, tightly coiled; gonoporal process moderately long, visibly covered by membrane to apex; secondary gonopore slightly flared, notched on one side; apical process short, cupped, unpigmented. Ovipositor with first valvula reaching about 3/5 distance to apex of connecting membrane; connecting membrane of first valve deeply notched medially, notch bordered by Y-shaped sclerite; second valvula broad, bluntly rounded apically; connecting membrane of second valve deeply cleft medially, heavily pigmented, not sclerotized. Spermatheca long, thin, complexly coiled distal to sperm pump; sperm pump moderately long, tubular, wider than basal tube; basal tube short, unpigmented.

Key to the Australian Species of Oncopeltus

1. Lateral pronotal margins very tumid, higher than center of posterior pronotal lobe, extending far laterad of base of hemelytra; pronotum purple except occasionally a small patch of red laterally; hemelytra never with a transverse median fascia but often with corium heavily infuscated apically . . . . *sordidus* (Dallas)

1′. Lateral pronotal margins at most moderately tumid, not higher than center of posterior pronotal lobe, extending only slightly laterad of base of hemelytra; pronotum usually red or orange with black or purple at anterior and posterior margins and sometimes median carina; hemelytra often with transverse median fascia 2

2. Pronotum red with anterior lobe anterior to callar impressions and a semicircular medial macula at base purple to black; antennal segment I usually more than 1 mm long . . *microps* Horváth

2′. Pronotum usually orange and black, if red then with anterior lobe black posterior of callar impressions and black mark at base not semicircular; antennal segment I less than 1 mm long 3

3. Posterior pronotal lobe completely covered with long, stout, upright hairs similar in size to those of lateral pronotal margins . . . . . *quadriguttatus* (Fabricius)

3′. Disc of posterior pronotal lobe with hairs finer, usually shorter and less upright than those on lateral pronotal margins 4

4. Hairs on disc of posterior pronotal lobe about as long as but much finer than those of lateral pronotal margin; smaller (♂ 7.1, ♀ 7.7 mm in length) . . . . . *purpurascens* Distant

4′. Hairs on disc of posterior pronotal lobe much shorter than those on lateral pronotal margin; larger (♂ at least 8.3, ♀ at least 9.8 mm in length) 5

5. Head above, except base behind eyes and ocelli, bright orange; scutellar hairs about as long and stout as hairs on lateral pronotal margins; antennal segment II usually longest . . . . . *nigroflavatus* Distant

5′. Head dorsally dark blackish purple; scutellar hairs much shorter and usually finer than hairs on lateral pronotal margins; antennal segment IV longest . . . . . *atrorufus* (Guérin)

Oncopeltus atrorufus *(Guérin 1831)*

Figures 43; 85g, h; 86j-l; 87a-c.

Lygaeus atrorufus Guérin, 1831:178.

Oncopeltus atrorufus Horváth, 1914:653, 657; Slater, 1964*a*:163.

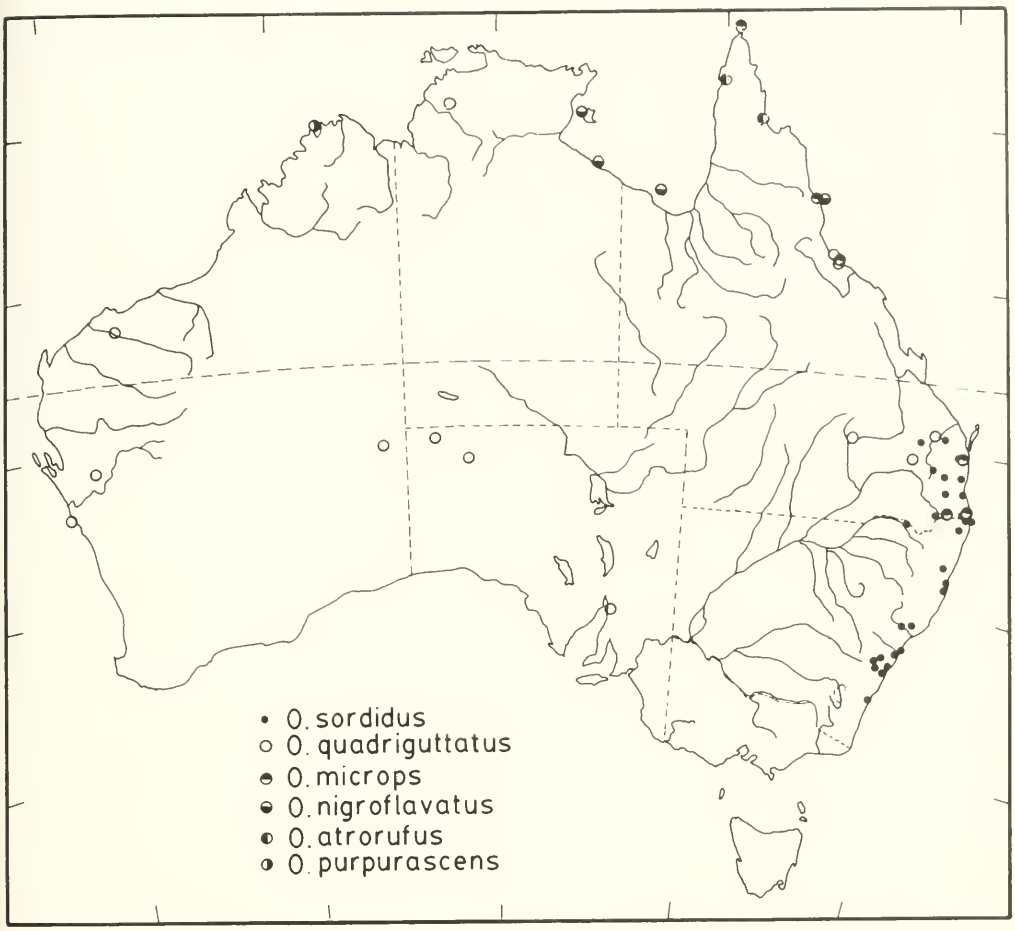


FIG. 43. Distribution of *Oncopeltus sordidus* (Dallas), *O. quadriguttatus* (Fabricius), *O. microps* Horváth, *O. nigroflavatus* Distant, *O. atrorufus* (Guerin), and *O. purpurascens* Distant in Australia.

Lygaeus dispar Walker, 1872:60; Slater, 1978:856.

Oncopeltus vagus Distant, 1918:418 (part); Slater, 1964*a*:173 (part); Slater, 1978:857 (part).

Oncopeltus bicinctus Slater, 1964*a*:164 (part).

Type.—Location of type and type locality unknown to me.

Redescription.—Color: Orange. The following blackish purple: head, anterior pronotal lobe except lateral margin of callus; posterior pronotal margin, sometimes extended forward medially to anterior lobe; base of scutellum; broad transverse median hemelytral fascia; center of prosternum; meso- and metasterna; center of propleuron; meso- and metapleura anteriorly; abdominal venter posteriorly, extending furthest anterad medially; antenna; labium; and legs. Head and appendages darkest. Eye brown. Ocellus orange. Hemelytral membrane brown; basal angle and sharply delineated, oblong, transverse discal macula white.

Structure: Rather narrow and elongate. Pronotum only moderately produced at posterior margin laterad of scutellum; lateral margin at most moderately tumid, lower than middle of

posterior lobe; scarcely extending laterad of hemelytral base; discal hairs of posterior lobe very short and fine. Scutellum usually with very short, fine hairs, these sometimes stouter and about half as long as hairs of lateral pronotal margin. Hemelytra with short, moderately fine hairs; costal margin of corium only slightly convex apically. Pygophore with long, moderately broad median projection. Clasper as in Figs. 86j-l; caudolateral lobe rather short; lateral projection moderately strongly produced and acute; transverse ridge of shank well developed. Aedeagus similar to *O. sordidus* (Fig. 85m); ejaculatory reservoir as in Figs. 85g, h. Ovipositor as in Figs. 87a, b. Spermatheca as in Fig, 87c; pigmented distal section short for genus.

Measurements: 7♂, 3♀. Length ♂ 9.4 (8.5-10.3), ♀ 10.3 (9.6-11.5); abdominal width ♂ 3.1 (2.7-3.3), ♀ 3.2 (3.0-3.5); head length ♂ .82 (.76-.90), ♀ .86 (.75-1.01); width across eyes ♂ 1.74 (1.66-1.84), ♀ 1.80 (1.70-1.94); pronotal length ♂ 1.65 (1.25-1.93), ♀ 1.68 (1.65-1.70); pronotal width ♂ 2.84 (2.45-3.16), ♀ 2.85 (2.75-2.94); scutellar length ♂ 1.29 (1.00-1.48), ♀ 1.36 (1.28-1.41); scutellar width ♂ 1.40 (1.18-1.55), ♀ 1.46 (1.43-1.48); length antennal segments I ♂ .84 (.76-.89), ♀ .84 (.80-.92), II ♂ 2.37 (2.08-2.57), ♀ 1.23 (1.21-1.25), III ♂ 2.01 (1.83-2.18), ♀ 1.98 (1.84-2.13), IV ♂ 2.72 (2.53-3.04), ♀ 2.59 (2.48-2.79); length labial segments I ♂ 1.19 (1.05-1.28), ♀ 1.23 (1.20-1.25), II ♂ 1.15 (1.03-1.25), ♀ 1.23 (1.21-1.25), III ♂ .77 (.69-.85), ♀ .80 (.79-.81), IV ♂ .89 (.85-.93), ♀ .94 (.93-.95).

Comments.—This species is very similar to *O. nigroflavatus* in general appearance but is generally lighter in color with the head darker and dark areas of the body more distinct. The long fourth antennal segment separates it from all but a few specimens of that species.

Oncopeltus atrorufus is widely distributed in and around New Guinea, in Australia reaching only to northern Queensland (Fig. 43). In other parts of its range the species shows variable coloration but the few Australian specimens seen have a consistent color pattern as described above. I have seen specimens from New Guinea that were almost completely blackish purple with a few small red areas and others which were almost completely orange. The Australian specimens examined have less intense dark coloration than do most specimens from New Guinea. Only one has a jet black head and appendages as do most New Guinea specimens. Two specimens examined have the vertex of the head more orange than purple, approaching *O. nigroflavatus* in that respect.

Oncopeltus microps *Horváth 1914*

Figures 43; 85i, j; 87g-i.

Oncopeltus microps Horváth, 1914:653-655; Slater, 1964*a*:169.

Type.—Type ♀, "Queensland: Mackey, W. W. Froggatt." in Budapest.

Redescription.—Color: Orange. The following dark blackish purple: head; anterior lobe of pronotum to level of callar impression, sometimes reaching anterior margin at anterolateral angle; large semicircular macula medially at posterior margin of pronotum, occasionally reaching lateral margin, often with narrow connection to dark area of anterior pronotal lobe; base of scutellum except often lateral margin; usually broad transverse median hemelytral fascia; meso- and metasterna; posterior half of acetabular margin of

propleuron; meso- and metapleura; abdominal venter posteriorly, extending furthest anterad medially; antenna; labium; and legs. Head, appendages, and base of scutellum darkest. Prothorax except dark areas red. Eye brown. Ocellus orange. Hemelytral membrane brown; basal angle and distinct, transverse, oblong discal macula white.

Structure: Variable in width from narrow to very broad. Pronotum rather flat; lateral margin moderately tumid, almost height of center of posterior lobe; extending very slightly lateral to base of hemelytron; discal hairs of posterior lobe short, fine. Scutellum with very short hairs. Hemelytra with short hairs; costal margin of corium moderately convex apically. Pygophore with moderately long median projection, very thin dorsally; submedian projection strongly developed. Clasper as in Figs. 87g, i; lateral projection very strongly developed, bladelike. Aedeagus similar to *O. sordidus* (Fig. 85m); ejaculatory reservoir as in Figs. 85i, j. Ovipositor similar to *O. atrorufus* (Figs. 87a, b). Spermatheca similar to *O. atrorufus* (Fig. 87c); distal tube longer.

Measurements: 9♂, 9♀. Length ♂ 10.0 (9.3-11.7), ♀ 11.2 (10.2-12.3); abdominal width ♂ 3.4 (3.03-3.7), ♀ 4.1 (3.4-4.6); head length ♂ 1.05 (.92-1.31), ♀ 1.00 (.91-1.13); width across eyes ♂ 1.79 (1.70-1.90), ♀1.91 (1.79-1.99); pronotal length ♂ 1.84 (1.74-2.10), ♀ 1.95 (1.75-2.19); pronotal width ♂2.97 (2.76-3.24) ♀ 3.52 (3.10-3.93); scutellar length ♂ 1.44 (1.30-1.58), ♀ 1.75 (1.55-1.98); scutellar width ♂ 1.48 (1.33-1.61), ♀ 1.85 (1.70-2.05); length antennal segments I ♂ 1.02 (.94-1.11), ♀ 1.03 (.89-1.10), II ♂ 2.83 (2.66-3.04), ♀ 2.81 (2.48-3.04), III ♂ 2.43 (2.23-2.56), ♀ 2.38 (2.13-2.50), IV ♂ 2.75 (2.66-2.89), ♀ 2.85 (2.80-2.88); length labial segments I ♂ 1.35 (1.25-1.45), ♀ 1.50 (1.38-1.55), II ♂ 1.29 (1.25-1.38), ♀ 1.43 (1.38-1.53), III ♂ .85 (.79-.91), ♀ .96 (.90-1.06), IV ♂ .93 (.88-.98), ♀ 1.10 (.98-1.05).

Comments.—The pronotal coloration of *O. microps* is very distinctive as are the claspers and the narrow median hypandrial projection. The width and coloration of the hemelytra are quite variable, ranging from very narrow to very wide and with or without a broad transverse median fascia. The species occurs throughout eastern Queensland but is apparently more common in the north than in the south (Fig. 43).

The type female is broad and lacks the hemelytral fascia. The eyes of that specimen are abnormally small, a state which led Horváth to name it *microps,* a misleading name as most specimens have eyes of average size for the genus.

Oncopeltus nigroflavatus
Distant 1918

Figures 43; 85e, f; 87d-f.

Oncopeltus nigroflavatus Distant, 1918: 418-419; Slater, 1964*a*:170.

Oncopeltus vagus Distant, 1918:418 (part); Slater, 1964*a*:173 (part); Slater, 1978:857 (part).

Type.—Type ♀, "Queensland, Mossman. Distant Coll. 1911-383." in BMNH.

Redescription.—Color: Orange, head redder than other parts. The following purplish-brown: base of head behind eye and ocellus; apex of anteclypeus; anterior pronotal lobe; posterior margin, wide longitudinal fascia, and sometimes lateral margin of posterior pronotal lobe; scutellum; broad transverse median hemelytral fascia; prosternum posteromedially; meso- and metasterna; propleuron medially; meso- and metapleura anteriorly; abdominal

venter posteriorly, extending farthest anterad medially; antenna; labium; and legs. Head behind eye, anteclypeus, callus; and base of pronotum darkest. Eye brown. Ocellus orange. Hemelytral membrane brown; basal angle and transverse, oblong, discal macula white.

Structure: Very similar to *O. atrorufus* but more robust. Scutellar hairs similar to those of lateral pronotal margin. Clasper as in Figs. 87d-f; caudolateral lobe long; transverse shelf of shank indistinct. Aedeagus similar to *O. sordidus* (Fig. 85m); ejaculatory reservoir as in Figs. 85e, f. Ovipositor similar to *O. atrorufus* (Figs. 87a, b). Spermatheca similar to *O. atrorufus* (Fig. 87c); thin distal tube comparatively longer.

Measurements: 10♂, 5♀. Length ♂ 9.5 (9.0-10.0), ♀ 10.9 (10.0-11.5); abdominal width ♂ 3.2 (3.1-3.3), ♀ 3.8 (3.5-4.0); head length ♂ .80 (.65-.91), ♀ .96 (.75-1.20); width across eyes ♂ 1.78 (1.69-1.85), ♀ 1.91 (1.83-1.99); pronotal length ♂ 1.73 (1.58-1.90), ♀ 1.93 (1.84-2.03); pronotal width ♂ 2.92 (2.71-3.05), ♀ 3.41 (3.31-3.48); scutellar length ♂ 1.35 (1.30-1.40), ♀ 1.59 (1.53-1.69); scutellar width ♂ 1.49 (1.43-1.60), ♀ 1.80 (1.68-1.91); length antennal segments I ♂ .78 (.74-.86), ♀ .84 (.78-.93), II ♂ 2.32 (2.18-2.43), ♀ 2.50 (2.34-2.69), III ♂ 1.94 (1.75-2.05), ♀ 2.01 (1.90-2.19), IV ♂ 2.30 (2.17-2.50), ♀ 2.36 (2.20-2.51); length labial segments I ♂ 1.21 (1.13-1.29), ♀ 1.33 (1.24-1.40), II ♂ 1.15 (1.08-1.21), ♀ 1.27 (1.16-1.31), III ♂ .75 (.69-.80), ♀ .82 (.80-.84), IV ♂ .89 (.83-.93), ♀ .99 (.95-1.03).

Comments.—*Oncopeltus nigroflavatus* is very similar to *O. atrorufus* in color and structure. They differ in that in the former the head dorsally is usually reddish orange and the second antennal segment longest while in the latter the head dorsally is usually dark blackish purple and the fourth antennal segment longest. The dark dorsal markings of *nigroflavatus* are often less clearly defined than those of *atrorufus*. The claspers and ejaculatory reservoirs of the two species also differ slightly. Three specimens of *nigroflavatus* from the Pellew Group, Northern Territory retain only traces of the dark dorsal markings.

Oncopeltus nigroflavatus apparently only occurs in northern Australia (Fig. 43).

Oncopeltus purpurascens
Distant 1901

Figures 43; 85k, l; 86a-c.

Oncopeltus purpurascens Distant, 1901*a*: 535; Slater, 1978:857.

Oncopeltus atrorufus var. *purpurascens* Horváth, 1914:653, 657-658; Slater, 1964*a*:163.

Types.—Lectotype ♂, "Baudin I. N.W. Aust. 90-126." in BMNH. Paralectotype ♀, same data as lectotype, in BMNH.

Redescription.—Color: Orange. Head, antenna, labium, and legs brownish red. The following brownish purple: anterior lobe of pronotum; posterior margin of pronotum; base of scutellum; broad, transverse median hemelytral fascia; meso- and metasterna; propleuron centrally; meso- and metapleura anteriorly; and abdominal venter posteriorly. Abdominal venter posteriorly darkest. Eye brown. Ocellus orange. Hemelytral membrane brown; basal angle and transverse, oblong discal macula white.

Structure: Small, narrow; appendages proportionately long and slender. Pronotum with lateral margin scarcely tumid, lower than center of posterior lobe; posterior margin scarcely produced caudally laterad of scutellum; hairs on disc of posterior pronotal lobe

very fine, somewhat shorter than hairs of lateral pronotal margin. Scutellar hairs fine, nearly as long as hairs of lateral pronotal margin. Hemelytra with costal margin of corium scarcely convex apically; hairs very short, fine. Pygophore with moderately short, broad, median projection. Clasper as in Figs. 86a-c; caudolateral lobe moderately long; lateral projection well developed; longitudinal ridges of shank almost straight, not produced into transverse ridge below blade or towards lateral projection. Aedeagus similar to *O. sordidus* (Fig. 85m); ejaculatory reservoir as in Figs. 85k, l. Ovipositor similar to *O. atrorufus* (Figs. 87a, b). Spermatheca similar to *O. atrorufus* (Fig. 87c).

Measurements: Lectotype ♂, paralectotype ♀. Length ♂ 7.1, ♀ 7.7; abdominal width ♂ 2.2, ♀ 2.4; head length ♂ .84, ♀ .95; width across eyes ♂ 1.38, ♀ 1.49; pronotal length ♂ 1.33, ♀ 1.38; pronotal width ♂ 2.13, ♀ 2.38; scutellar length ♂ .96, ♀ 1.00; scutellar width ♂ 1.08, ♀ 1.13; length abdominal segments I ♂ .63, ♀ .64, II ♂ 1.78, ♀ 1.79, III ♂ 1.58, ♀ 1.56, IV ♂ 1.93, ♀ 1.92; length labial segments I ♂ 1.00, ♀ 1.13, II ♂ .98, ♀ 1.10, III ♂ .59, ♀ .64, IV ♂ .74, ♀ .80.

Comments.—Oncopeltus purpurascens is known only from the lectotype male and paralectotype female. It is the smallest known Australian member of the genus. This species is very similar to *O. nigroflavatus* and *O. atrorufus* in general appearance and may prove to be conspecific with one of them. The differences in structure of the genitalia could be due to the smaller size and those in coloration due to environmental factors. However, on the basis of the available material, it must be treated as a separate species.

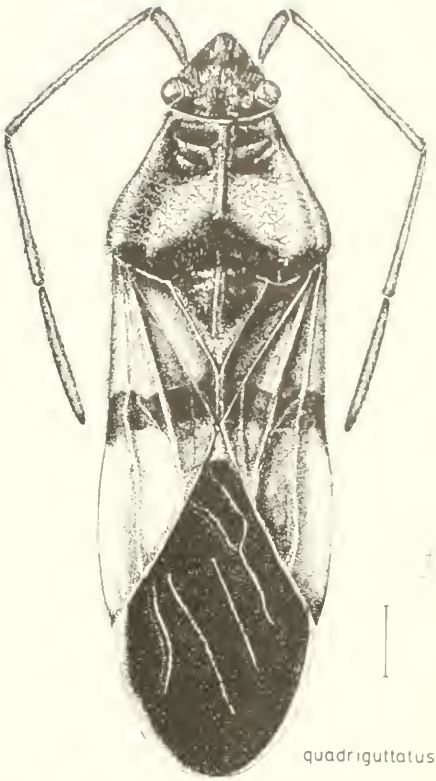


FIG. 44. *Oncopeltus quadriguttatus* (Fabricius), dorsal view. Scale = 1 mm.

Oncopeltus quadriguttatus
(Fabricius 1775)

Figures 43; 44; 85c, d; 86g-i.

Cimex quadriguttatus Fabricius, 1775: 720.

Lygaeus quadriguttatus Fabricius, 1794: 157.

Lygaeus castaneipes Dallas, 1852:536, syn. nov.

Lygaeus innotatus Dallas, 1852:537, syn. nov.

Lygaeus contiguus Walker, 1872:62.

Oncopeltus quadriguttatus Stål, 1874:101; Slater, 1964*a*:170-171.

Pyrrhobaphus contiguus Lethierry and Severin, 1894:150.

Oncopeltus sordidus var. *castaneipes* Horváth, 1914:654; Slater, 1964*a*:172-173, syn. nov.

Oncopeltus consors Distant, 1918:418;

Slater, 1964*a*:165; Slater, 1978:856, syn. nov.

Types.—Neotype ♂ of *quadriguttatus,* "Palm Island, M. S. Mackerras." in ANIC. Designated here. Type ♀ of *castaneipes,* in BMNH. Type ♀ of *innotatus,* in BMNH. Type ♀ of *contiguus,* in BMNH. Lectotype ♂, paralectotype ♂, ♀, and ? of *consors,* in BMNH.

Redescription.—Color: Variable. What follows is a general pattern from which divergences will be discussed under comments. The following dull orangey red: head except base behind eye and ocellus; posterior pronotal lobe except midline and posterior margin; prosternum anteriorly and centrally; and propleuron except center. The following blackish purple: head behind eye and ocellus; anterior lobe, midline, and posterior margin of pronotum; base of scutellum; broad, transverse median hemelytral fascia; prosternum posteriorly; meso- and metasterna; propleuron except center; meso- and metapleura except posterior margins and ostiolar peritreme; abdominal venter posteriorly, extending farthest forward medially; antenna; labium; and legs. Eye brown. Ocellus orange. Hemelytral membrane brown; basal angle and small, transverse, oblong discal macula white.

Structure: Moderately robust. Pronotum scarcely projecting laterad of base of hemelytra; lateral margin slightly to moderately tumid, lower than center of posterior lobe; posterior margin slightly to moderately produced posteriorly lateral of scutellum; discal hairs of posterior lobe long, stout, at least approaching size of hairs on lateral margin. Hemelytra with costal corial margin slightly to moderately convex apically; hairs moderately long and stout, shorter than hairs of pronotum. Pygophore with moderately long median projection. Clasper as in Figs. 86g-i; caudolateral lobe elongate; lateral projection blunt; shank with longitudinal ridge extended towards lateral projection as transverse dorsal ridge, not extending under blade. Aedeagus similar to *O. sordidus* (Fig. 85m); ejaculatory reservoir as in Figs. 85c, d. Ovipositor similar to *O. atrorufus* (Figs. 87a, b). Spermatheca similar to *O. atrorufus* (Fig. 87c) but pigmented distal tube longer.

Measurements: Length ♂ 9.4 (7.0-10.4), ♀ 10.2 (7.8-12.3); abdominal width ♂ 3.2 (2.3-3.5), ♀ 3.4 (2.5-4.1); head length ♂ .89 (.81-1.10), ♀ 1.04 (.83-1.20); width across eyes ♂ 1.74 (1.49-1.85), ♀ 1.80 (1.53-2.08); pronotal length ♂ 1.72 (1.39-2.00), ♀ 1.65 (1.48-2.18); pronotal width ♂ 2.88 (2.18-3.33), ♀ 3.16 (2.44-3.88); scutellar length ♂ 1.42 (.91-1.68), ♀ 1.50 (1.03-2.08); scutellar width ♂ 1.67 (1.09-1.73), ♀ 1.62 (1.30-2.00); length antennal segments I ♂ .76 (.58-.85), ♀ .75 (.58-.88), II ♂ 2.16 (1.61-2.51), ♀ 2.13 (1.61-2.63), III ♂ 1.82 (1.36-2.18), ♀ 1.69 (1.34-1.99), IV ♂ 2.14 (1.68-2.51), ♀ 1.94 (1.63-2.24); length labial segments I ♂ 1.19 (.93-1.35), ♀ 1.12 (1.06-1.43), II ♂ 1.10 (.90-1.18), ♀ 1.19 (1.00-1.38), III ♂ .71 (.58-.79), ♀ .74 (.61-.86), IV ♂ .85 (.70-.90), ♀ .89 (.78-1.00).

Measurements neotype ♂. Length 10.2; abdominal width 3.5; head length .82; width across eyes 1.85; pronotal length 1.80; pronotal width 2.91; scutellar length 1.68; scutellar width 1.68; length antennal segments I .83, II 2.30, III 1.94, IV 2.39; length labial segments I 1.20, II 1.15, III .74, IV .86.

Comments.—This species is variable in both size and coloration. The presence of long stout hairs on all parts of

the pronotum is the best diagnostic character.

Oncopeltus quadriguttatus was described by Fabricius from material in the Banks Collection from "Nova Hollandia". Zimsen (1964) did not record the location of the type specimen. Mr. W. D. Dolling of the British Museum (Natural History) has confirmed that the type is not contained in the Banks Collection which is presently housed in that institution. As Fabricius' original description could refer to almost any species of *Oncopeltus* and as there are several very similar species in the genus it is important that the name be fixed to a type specimen. I am therefore designating as neotype a specimen from northern Queensland in the ANIC. The type specimen was chosen as being from a place visited by Banks during Cook's voyage, showing coloration and structure typical of the species in that part of Australia, and in good condition.

The species as I understand it is variable in coloration. The lighter coloration varies from brick red to pale orange and the darker coloration from brownish purple to dark blackish purple. The light areas of the head and pronotum are usually but not always darker than those of the hemelytra and abdomen. The dark hemelytral markings are completely absent on some specimens and on others occupy the whole of the coriaceous part except the basal ¼. The entire venter except the extreme base of the abdomen and the ostiolar peritreme is dark blackish purple in some specimens. In those specimens the normally darker areas are indicated by intensity rather than differences in color.

As the color of specimens from a given geographical area tends to be consistent it is possible that what I consider one species is in fact an assemblage of closely related species. However, I can find no consistent differences in either external structure or genitalia. I believe that it is in fact one species with differences in coloration reflecting local environmental conditions as is the case with many other Heteroptera. The great variation in size may also be due to direct influence of the environment. A series of specimens from Western Australia housed in the ANIC and collected in the spring are generally smaller than those of a series collected at the same place in the autumn.

I have seen specimens from North Stradbroke Island, Queensland, in the collection of the University of Queensland and from Eidsvold, Queensland, in the Australian Museum and ANIC which appear intermediate between *O. quadriguttatus* and *O. sordidus* in coloration and in structure of the pronotum. The Stradbroke Island population is particularly interesting in that it shows great variation in color pattern and contains specimens with and without long stout hairs on the disc of the posterior pronotal lobe. I believe that the two populations consist of hybrids of *O. quadriguttatus* and *O. sordidus*. As the localities are near the southeastern and northern ends of their respective ranges this seems a good possibility.

In light of the probable existence of hybrid populations the possibility that the two species should be considered at most subspecies must be taken into consideration. The structural differences are so great that I believe it much more likely that they are separate species with quite different tolerances for such conditions as temperature and humidity but which are capable of hybridization where both can survive during at least part of the year. Cytological studies and/or controlled breeding experiments will likely be necessary

to answer this question satisfactorily.

Oncopeltus quadriguttatus, as considered here, occurs throughout the interior of Australia reaching the coast in dryer areas (Fig. 43).

Oncopeltus sordidus *(Dallas 1852)*

Figures 43; 45, 85a, b, m-o; 86d-f.

Lygaeus sordidus Dallas, 1852:536.

Oncopeltus quadriguttatus Froggatt (*nec* Fabricius), 1901:1598; Froggatt (*nec* Fabricius), 1907:333-334; Froggatt (*nec* Fabricius), 1923:202-209; Gurney (*nec* Fabricius), 1924:138; Hargreaves (*nec* Fabricius), 1948:29.

Oncopeltus sordidus Froggatt, 1907:333-334; Tillyard, 1926:147; Slater, 1964*a*:172.

Type.—Type ♂, no locality label, in BMNH.

Redescription.—Color: Orange. Head except base behind eye and ocellus, apex of anteclypeus, buccula, and gular area red. The following purplish-black: head behind eye and ocellus; apex of anteclypeus; callus; base of scutellum; prosternum posteriorly; meso- and metasterna; propleuron centrally; meso- and metapleura except posteriorly and ostiolar peritreme; antenna; labium; and legs. The following dark purple: buccula; gular area; pronotum except callus; prosternum anteriorly; propleuron except centrally; meso- and metapleura posteriorly; and abdominal venter posteriorly, extending farthest forward medially. Eye, ostiolar peritreme, and often apex of corium brown. Ocellus red. Hemelytral membrane brown; basal angle (indistinctly) and discal macula white.

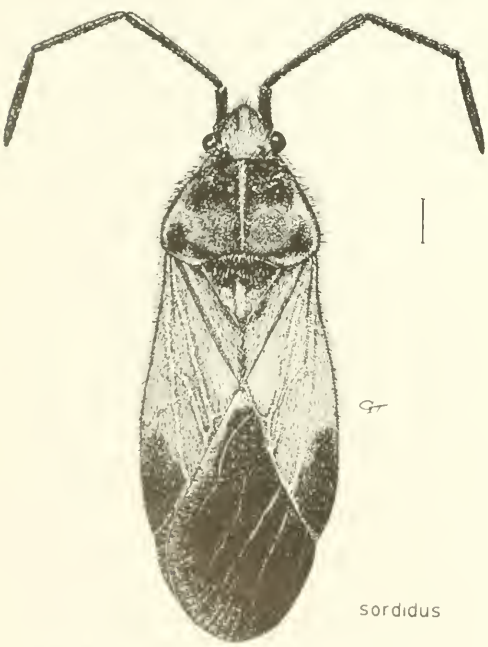


FIG. 43. *Oncopeltus sordidus* (Dallas), dorsal view. Scale = 1 mm.

Structure: Large, robust. Pronotum with extremely tumid lateral margins, higher than center of posterior lobe, extending considerably lateral to base of hemelytron; posterior margin strongly produced posteriorly lateral of scutellum; discal hairs of posterior lobe much shorter, finer than hairs of lateral margin. Scutellar hairs moderately long and stout, much shorter and finer than those of lateral pronotal margin. Hemelytra much wider medially than basally; costal margin of corium moderately strongly convex apically; hairs short. Pygophore as in Figs. 85n, o; median projection rather short, broad. Clasper as in Figs. 86d-f; caudolateral lobe short; lateral projection moderately strongly produced; longitudinal ridge of shank strongly developed, extending dorsally as transverse ridge towards lateral projection and under blade. Aedeagus as in Fig. 85m; ejaculatory reservoir as in Figs. 85a, b. Ovipositor similar to *O. atrorufus* (Figs. 86k, l). Spermatheca similar to *O. atrorufus* (Fig. 87c) but distal pigmented tube very long.

Measurements: Length ♂ 11.5 (10.1-12.4), ♀ 12.7 (10.7-14.1); ab-

dominal width ♂ 4.4 (3.8-4.9), ♀ 5.0 (3.9-5.7); head length ♂ 1.03 (.92-1.24), ♀ 1.10 (.88-1.20); width across eyes ♂ 2.01 (1.86-2.16), ♀ 2.04 (1.88-2.22); pronotal length ♂ 2.07 (1.80-2.20), ♀ 2.22 (1.88-2.44); pronotal width ♂ 3.85 (3.50-4.44), ♀ 4.29 (3.66-4.78); scutellar length ♂ 1.76 (1.56-1.92), ♀ 2.06 (1.50-2.40); scutellar width ♂ 1.79 (1.60-1.90), ♀ 2.06 (1.64-2.32); length antennal segments I ♂ .96 (.88-1.10), ♀ .98 (.84-1.06), II ♂ 2.79 (2.52-3.27), ♀ 2.52 (2.32-3.04), III ♂ 2.26 (2.00-2.63), ♀ 2.23 (1.87-2.38), IV ♂ 2.45 (2.24-2.68), ♀ 2.45 (2.16-2.72); length labial segments I ♂ 1.34 (1.24-1.48), ♀ 1.46 (1.30-1.56), II ♂ 1.28 (1.22-1.40), ♀ 1.34 (1.22-1.42), III ♂ .87 (.80-.96), ♀ .94 (.84-1.04), IV ♂ 1.00 (.88-1.12), ♀ 1.03 (.92-1.06).

Comments.—*Oncopeltus sordidus* is easily recognized by the structure of the pronotum. The coloration of the thorax is somewhat variable, sometimes being so dark that the darker areas are scarcely differentiated and sometimes nearly completely red or with a small red macula behind each callus. The lighter coloration of the hemelytra is occasionally almost the same color as the head.

Froggatt (1901) recorded this species, under the name *O. quadriguttatus,* as breeding on cotton in New South Wales. Subsequent authors have repeated his observations under both names *quadriguttatus* and *sordidus.* While Froggatt's description of the adult leaves no doubt that it is this species, his description of the egg and nymph leaves no doubt that they are not. The placement of eggs in a ring around a twig and the flat round nymph, red in color and mottled with metallic blue spots, seem more likely to be those of *Tectocoris diophthalmis* (Thunberg) (Scutelleridae).

Oncopeltus sordidus has been collected on *Nerium oleander, Araujia hortorum,* and *Hoya* sp. There appears to be some hybridization with *O. quadriguttatus* in southern Queensland. A male and a female of *Alophora aureiventris* Curran (Tachinidae) emerged from specimens collected at Yarraman, Queensland.

Oncopeltus sordidus is restricted to southeastern Australia (Fig. 43).

Literature Cited

Ashlock, P. D. 1957. An investigation of the taxonomic value of the phallus in the Lygaeidae (Hemiptera—Heteroptera). Ann. Entomol. Soc. Amer. 50:407-426.

———. 1975. Toward a classification of North American Lygaeinae (Hemiptera—Heteroptera: Lygaeidae). J. Kansas Entomol. Soc. 48:27-32.

Atkinson, E. T. 1882. Notes on the Zoology of the N.W.P. India. Privately printed?, St. Leonard's-on-Sea. 266 p.

Ballard, E. 1927. Some insects associated with cotton in Papua and the mandated territory of New Guinea. Bull. Entomol. Res. 17:295-300.

Barber, H. G. 1958. Insects of Micronesia Heteroptera: Lygaeidae. Insects Micronesia 7:173-218.

Bergroth, E. 1914. H. Sauter's Formosa-Ausbeute; Hemiptera Heteroptera I. Entomol. Mitt. 3:353-364.

———. 1916. Heteropterous Hemiptera collected by Prof. W. Baldwin Spencer during the Horn expedition into central Australia. Proc. R. Soc. Victoria 29:1-18.

———. 1918. Studies in Philippine Heteroptera I. Philipp. J. Sci., Sect. D. 13:43-126.

Blöte, H. C. 1972. On some Lygaeidae of the genus *Astacops* and allies. Zool. Meded. Rijks Mus. Nat. Hist. Leiden 47:410-413.

Boisduval, J. B. A. 1835. Voyage de découvertes de L'Astrolabe, exécuté pendant les années 1826-1827-1828-1829, sous le commandement de m. J Dumont d'Urville. Faune entomologique de L'Ocean Pacifique, avec l'illustration des insectes nouveaux recueillis pendant le voyage, Vol. 2. J Tastu, Paris. 716 p.

Breddin, G. 1900. Nova studia Hemipterologica Dtsch. Entomol. Z. 1900:161-185.

———. 1901. Die Hemipteren von Celebes Abh Naturforsch. Ges. Halle 24:1-213.

———. 1905. Rhynchota Heteroptera aus Java Mitt. Naturhist. Mus. Hamburg 22:111-159

———. 1907. Berytiden und Myodochiden von Ceylon aus der Sammelausbeute von Dr W Horn (Rhynch, het.). Dtsch. Entomol. Z 1907.34-47

Chatterjee, N. C. 1937. (Entomology) Indian For Rec., new ser. 3:105-121

China, W. E. 1930. Insects of Samoa and other

Samoan terrestrial Arthropoda. Part II. Hemiptera. Fasc. 3:81-162. British Museum (Natural History), London.

DALLAS, W. S. 1852. List of the Specimens of Hemipterous Insects in the Collection of the British Museum. Part 2. Taylor & Francis Inc., London. 224 p.

DISTANT, W. L. 1888. An enumeration of the Rhynchota received from Baron von Muller and collected by Mr. Sayer in New Guinea during Mr. Cuthbertson's expedition. Trans. R. Entomol. Soc. London 1888:475-489.

———. 1892. A Naturalist in the Transvaal. R. H. Porter, London. 277 p.

———. 1901*a*. Rhynchotal notes. X. Heteroptera: Fam. Lygaeidae. Ann. Mag. Nat. Hist. ser. 7, 7:531-541.

———. 1901*b*. Rhynchotal notes. XI. Heteroptera: Lygaeidae. Ann. Mag. Nat. Hist. ser. 7, 8:464-486, 497-510.

———. 1904. Fauna of British India, Including Ceylon and Burma. Rhynchota. Vol. 2. (Heteroptera). Taylor & Francis, London. 503 p.

———. 1906. Oriental Heteroptera. Ann. Soc. Entomol. Belg. 50:405-417.

———. 1910. The Fauna of British India, Including Ceylon and Burma. Rhynchota. Vol. 5. Heteroptera: Appendix. Taylor & Francis, London. 362 p.

———. 1914. Rhynchota from New Caledonia and the surrounding islands, p. 369-390. *In* C. F. Sarasin and J. Roux (eds.), Nova Caledonia. Forschungen in Neu-Caledonien und auf den Loyalty-Inseln. Recherches scientifiques en Nouvelle Calédonie et aux Îsles Loyalty. A. Zoologie. Vol 1. C. W. Kreidel, Wiesbaden. 446 p.

———. 1918. Contributions to a further knowledge of the Rhynchotal family Lygacidae. Ann. Mag. Nat. Hist. ser. 9, 2:173-179, 257-270, 416-424, 486-492.

DOHRN, F. A. 1859. Catalogus Hemipterorum. Herrcke, Stettin. 112 p.

ERICHSON, W. F. 1842. Beitrag zur Insekten-fauna von Vandiemansland mit besonderer Berucksichtigung der geographischen Verbreitung der Insekten. Arch. Naturgesch. 8:83-287.

FABRICIUS, J. C. 1775. Systema entomologiae, sistens insectorum classes, ordines, genera, species, adiectis synonymis, locis, descriptionibus, observationibus. Korte, Flensburgi et Lipsiae. 832 p.

———. 1781. Species insectorum, exhibentes eorum differentias specificas, synonyma auctorum, loca natalia, metamorphosen, adiectis observationibus, descriptionibus . . . Vol. 2. Ernst Bohnii, Hamburg et Kilonii. 832 p.

———. 1787. Mantissa insectorum sistens eorum species nuper detectas adiectis characteribus generici differentiis specificis, emendationibus, observationibus. Vol 2. C. G. Proft, Hafniae. 382 p.

———. 1794. Entomologica systematica emendata et aucta, secundum classes, ordines, genera, species, adjectis synonymis, locis, observationibus, descriptionibus . . . Vol. 4. C. G. Proft, Hafniae. 472 p.

———. 1798. Supplementum entomologiae systematicae. Proft et Storch, Hafniae. 572 p.

FIEBER, F. X. 1860-1861. Die Europaischen Hemiptera. Halbflugler (Rhynchota Heteroptera). Gerold, Wien. 444 p. (Introductory generic key published in 1860.)

FROGGATT, W. W. 1901. Notes on Australian Hemiptera. Agric. Gaz. New South Wales 12:1592-1599.

———. 1907. Australian Insects. William Brooks & Co. Ltd., Sydney. 449 p.

———. 1923. Insect pests of the cultivated cotton plant no. 3. Cotton stainers and other plant bugs. Agric. Gaz. New South Wales 34:209-212.

GMELIN, J. F. 1790. Caroli a Linne. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis . . . ed. 13, aucta, reformata. Vol. 1, part 4. G. E. Beer, Lipsiae. 707 p.

GROSS, G. F. 1965. On the identity of *Lygaeus mutilatus* Erichson (Hemiptera: Lygaeidae). J. Entomol. Soc. Queensland 4:24-26.

GUÉRIN, F. E. 1831. Crustacés, Arachnides et Insectes. *In* L I. Duperrey, Voyage autour du monde, exécuté par ordre du roi, sur la corvette de Sa Majesté, La Coquille, pendant les années 1822, 1823, 1824 et 1825, sous le Ministère et conformément aux instructions de S.E.M. le marquis Clermont-Tonnerre, ministre de la marine; et publié sous les auspices de son excellence msr. le cte. de Chabrol, ministre de la marine et des colonies. Vol. 2, part 2, div. 1. Arthur Bertrand, Paris. 319 p.

GURNEY, W. B. 1924. Insect pests of cotton in New South Wales. Agric. Gaz. New South Wales 34: 887-893; 35:49-55, 137-138, 422-428.

HAMID, A. and K. MEHER. 1973*a*. The genera of Lygaeinae (Heteroptera: Lygaeidae) in West Pakistan. Pakistan J. Sci. Ind. Res. 16:35-38.

———. 1973*b*. The Lygaeinae of West Pakistan. Part I. *Spilostethus* (Heteroptera: Lygaeidae) in West Pakistan. Pakistan J. Sci. Ind. Res. 16:188-192.

HARGREAVES, H. 1948. List of Recorded Cotton Insects of the World. Commonwealth Institute of Entomology, London. 50 p.

HERRICH-SCHAEFFER, G. H. W. 1843. Die Wanzenartigen Insekten. Part 8. C. H. Zeh'schen Buchhandlung, Nurnberg. 30 p.

HOFFMAN, W. E. 1932. The economic status of the lygaeids and notes on the life history of *Lygaeus hospes* Fabr. and *Aphanus sordidus* Fabr. (Hemiptera: Lygaeidae). Lingnan Sci. J. 11:119-135.

———. 1934. The life history of a species of *Graptostethus* (Hemiptera: Lygaeidae). Lingnan Sci. J. 13:171-176.

HORVÁTH, G. 1902. Descriptions of new Hemiptera from New South Wales. TermTud. Fuz. 25:601-612.

———. 1914. Miscellanea Hemipterologica XIII-XVII. Ann. Hist.-Nat. Mus. Nat. Hung. 12:623-660.

HUTTON, F. W. 1874. List of the insects recorded as having been found in New Zealand previous to the year 1870. Trans. N.Z. Inst. 6:158-182.

———. 1898. Synopsis of the Hemiptera of New Zealand which have been described previous to 1896. Trans. N.Z. Inst. 30:167-187.

KIRITSHENKO, A. N. 1950. Hemiptera, p. 348-365. *In*

E. N. Pavlovskii and B. S. Vinogradov (eds.), Animal World USSR. Vol. 3. (Not seen.)

Kirkaldy, G. W. 1903. Einige neue und wenig bekannte Rhynchoten. Wien. Entomol. Ztg. 22:13-17.

———. 1905. Memoir on the Rhynchota collected by Dr. Arthur Willey, F.R.S. chiefly in Birora (New Britain) and Lifu. Trans. R. Entomol. Soc. London 1905:327-363.

———. 1908. A catalogue of the Hemiptera of Fiji. Proc. Linn. Soc. New South Wales 33:345-391.

———. 1909. A list of the Hemiptera of the Maorian sub-region. Trans. N.Z. Inst. 41:22-29.

Lethierry, L. and G. Severin. 1894. General catalogue of the Hemiptera. Vol. 2. Heteropteres. F. Hayez, Brussels. (Not seen.)

Lever, R. J. A. W. 1937. Economic insects and biological control in the British Solomon Islands. Bull. Entomol. Res. 28:325-331.

Malipatil, M. B. 1979. The biology of some Lygaeidae (Hemiptera: Heteroptera) of south-east Queensland. Aust. J. Zool. 27:231-249.

Mayr, G. L. 1868. Hemiptera. *In* H. K. von Scherzer (ed.), Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859 unter den befehlen des Commodore B. von Wüllerstorf-Urbair. Zoologischer Teil. Vol. 2, part 5. Karl Gerold's Sohn, Wien. 204 p.

Montrouzier, P. 1861. Essai sur la faune entomologique de la Nouvelle Calédonie. Ann. Soc. Entomol. Fr. ser. 4, 1:59-74.

Puton, A. 1869. Description de trois Hemipteres nouveaux du Sahara algerien, et remarques sur une variete. Ann. Soc. Entomol. Fr. 1869:139-144.

Reuter, O. M. 1885. Ad cognitionem Lygaeidarum Palaearcticarum. Rev. Entomol. Caen 4:199-233.

———. 1912. Hemipterologische Miscellen. Öfvers. Finska VentenskSoc. Forh. 54:1-76.

Scopoli, J. A. 1763. Entomologia carniolica exhibens Insecta Carnioliae indigena et distributa in ordines genera, species, varietates, methodo Linnaeanna. Trattner, Vindobonae. 420 p.

Scudder, G. G. E. 1963. A revision of the genus *Astacops* sensu lat. (Hemiptera: Lygaeidae). Pac. Insects 5:315-415.

———. 1965. *Neacoryphus* Scudder, a new genus of Lygaeinae (Hemiptera: Lygaeidae). Proc. Entomol. Soc. British Columbia 62:34-37.

———. 1968. Air-borne Lygaeidae (Hemiptera) trapped over the Atlantic, Indian and Pacific oceans, with the description of a new species of *Appolonius* Distant. Pac. Insects 10:155-160.

Scudder, G. G. E. and S. S. Duffey. 1972. Cardiac glycosides in the Lygaeinae (Hemiptera: Lygaeidae). Can. J. Zool. 50:35-42.

Slater, A. 1978. Taxonomic notes on Lygaeniae from Australia and neighboring areas (Heteroptera: Lygaeidae). Ann. Entomol. Soc. Amer. 71: 854-858.

Slater, J. A. 1957. Nomenclatoral considerations in the family Lygaeidae (Hemiptera: Heteroptera). Bull. Brooklyn Entomol. Soc. 52:35-38.

———. 1964*a*. A Catalogue of the Lygaeidae of the World. Vol. 1. Univ. Connecticut, Storrs. 778 p.

———. 1964*b*. Hemiptera (Heteroptera): Lygaeidae. S. Afr. Anim. Life 10:15-228.

Slater, J. A. and B. Sperry. 1973. The biology and distribution of the South African Lygaeinae, with descriptions of new species (Hemiptera: Lygaeidae). Ann. Transvaal Mus. 28:119-201, pl. 3.

Spinola, M. 1837. Essai sur les genres d'insectes appartenants a l'ordre des Hemipteres Lin. ou Rhyngotes Fab. et la section Heteropteres, Dufour. Chez Gravier Imprimeur—Libraire, Genes. 383 p.

Stål, C. 1858. Orthoptera och Hemiptera fran sodra Afrika. Öfvers. VetenskAkad. Forh. Stockholm 13: 193-199.

———. 1859. Hemiptera, Species novas descriptsit, p. 219-298. *In* C. A. Virgin, Konglika Svenska Fregattens Eugenies resa omkring Jorden under Befäl af C. A. Virgin, aren 1851-1853. Vol. 2, part 1. Norstedt, Stockholm. 617 p.

———. 1865. Hemiptera nova vel minus cognita. Ann. Soc. Entomol. Fr. ser. 4, 5:163-188.

———. 1867. Analecta Hemipterologica. Berliner Entomol. Z. 10:151-172, 381-394.

———.1868. Hemiptera Fabriciana. T. K. Svenska VetenskAkad. Handl. 7:1-148.

———. 1870. Hemiptera insularum Philippinarum-bidrag till Philippinska oarnes Hemipteren-launa. Öfvers. VetenskAkad. Forh. 27:607-776.

———. 1872. Genera Lygaeidarum Europae disposuit. Öfvers. VetenskAkad. Forh. 29:37-62.

———. 1874. Enumeratio Hemipterorum. Pt. 4. K. Svenska VetenskAkad. Handl. 12:1-186.

Thunberg, C. P. 1822. Dissertatio entomologica de Hemipteris rostratis Capensibus. Part 4. Acad. Typogr., Upsaliae. 6 p.

Tillyard, P. 1926. The Insects of Australia and New Zealand. Angus & Robertson, Ltd., Sydney. 560 p.

Tryon, H. 1892. Zoology of British New Guinea. II. Hemiptera. Ann. Queensland Mus. 2:13-24.

Turton, W. 1800. A General System of Nature Through the Three Grand Kingdoms etc., Vol. 2. Voss & Morris, Swansea. 717 p.

Uhler, P. R. 1860. Hemiptera of the North Pacific Exploring Expedition under Com'rs. Rodgers and Ringgold. Proc. Acad. Nat. Sci. Philadelphia. 12: 221-231.

Walker, F. 1872. Catalogue of the Specimens of Hemiptera Heteroptera in the Collection of the British Museum. Part 5. British Museum (Natural History), London. 202 p.

White, F. B. 1878. List of the Hemiptera of New Zealand. Entomol. Mon. Mag. 15:31-34, 73-76.

Wolff, J. F. 1802. Icones Cimicum descriptionibus illustratae. Part 3. Joann. Jacobum Palm, Erlangae. 40 p.

Woodward, T. E. 1962. Lectotype selection for three of Erichson's species of Australian Lygaeidae (Hemiptera: Heteroptera). J. Entomol. Soc. Queensland 1:50-66.

Zimsen, E. 1964. The Type Material of J. C. Fabricius. Munksgaard, Copenhagen. 656 p.

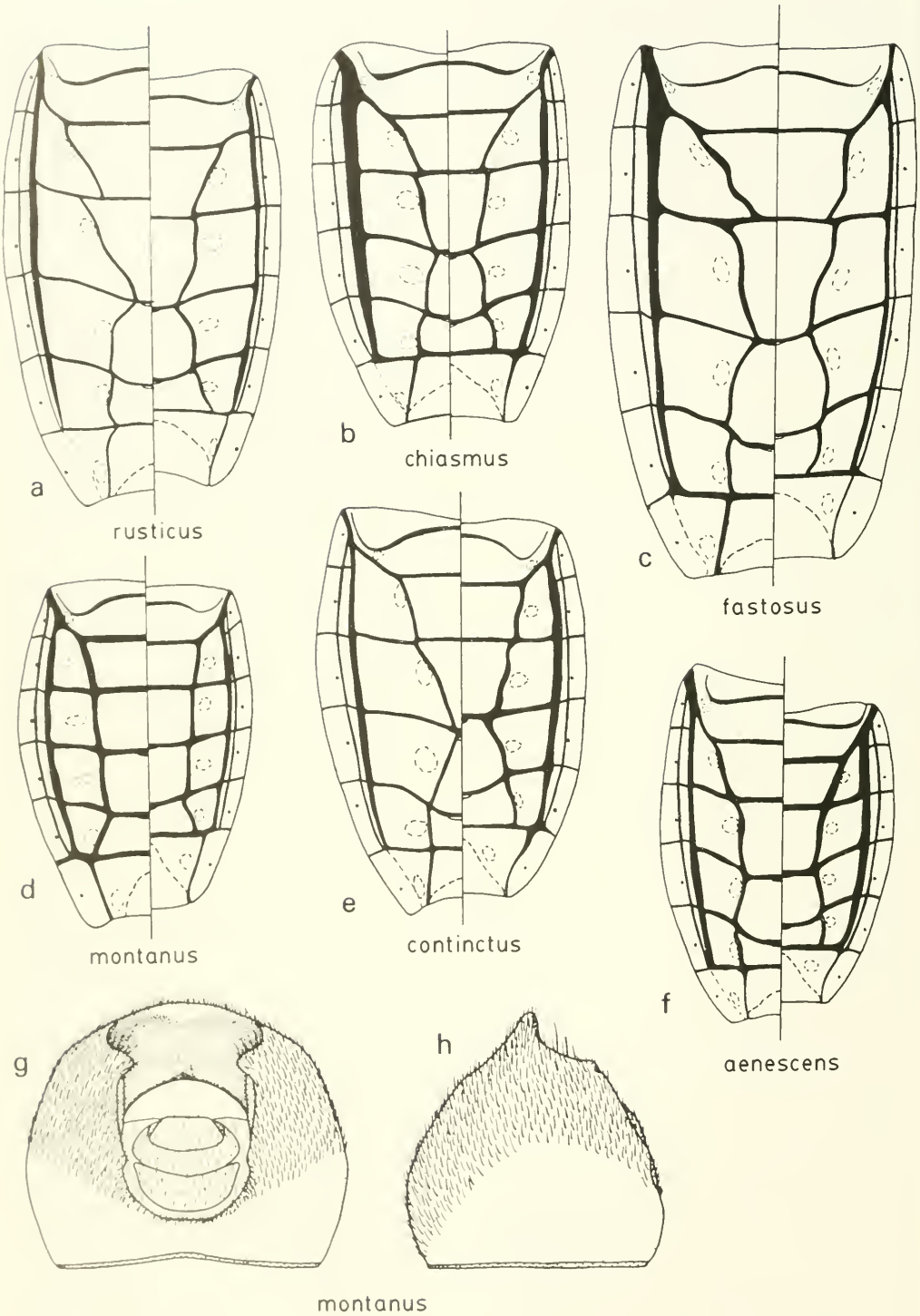


FIG. 16. *Trocatus* spp. a-f. Abdominal dorsum of named species: female left half, male right half. g, h. *A. montanus*, sp. nov., pygophore: g, dorsal view; h, lateral view.

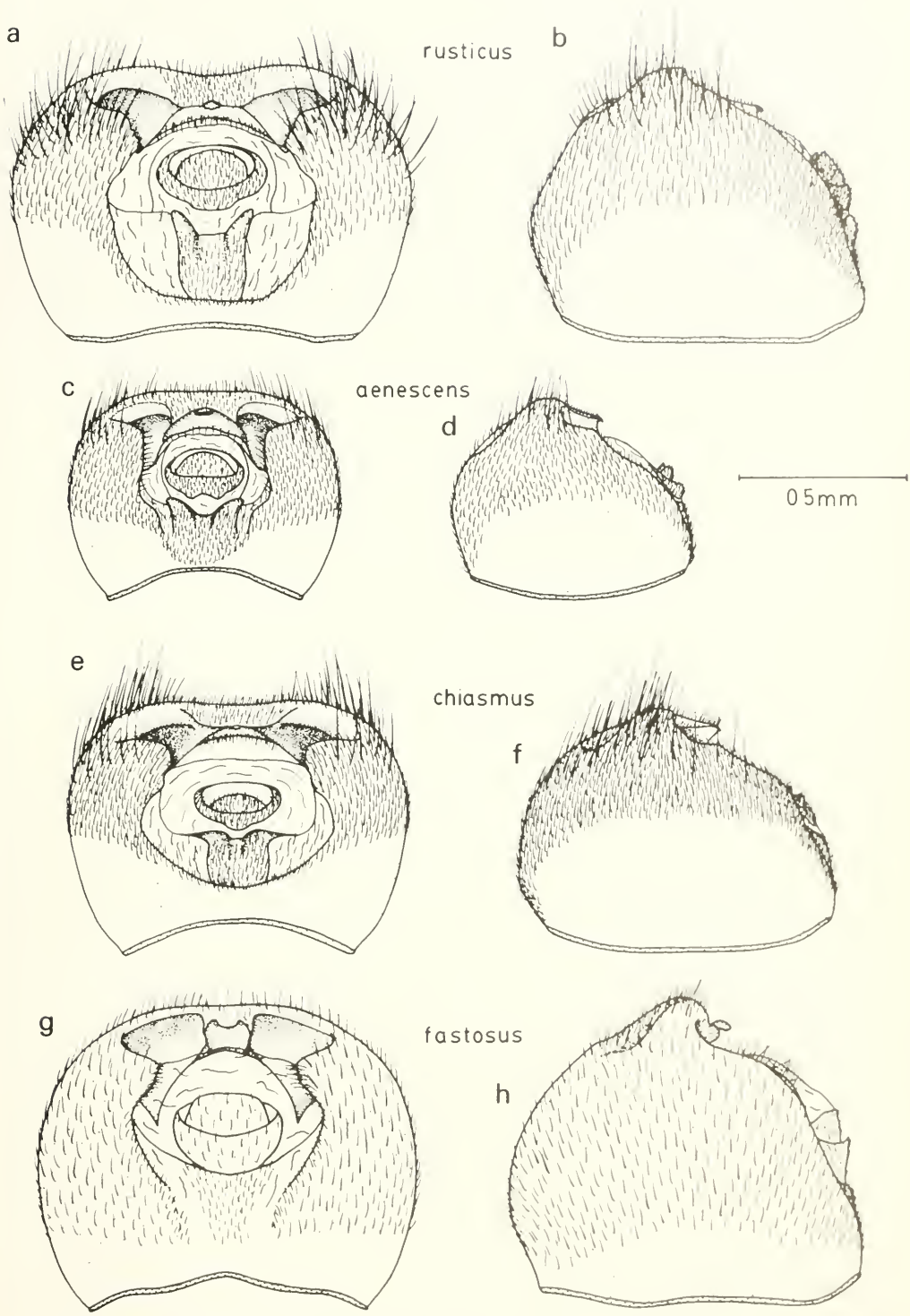


FIG. 47. *Arocatus* spp. a-h. Pygophore of named species: a, c, e, g, dorsal view, b, d, f, h, lateral view

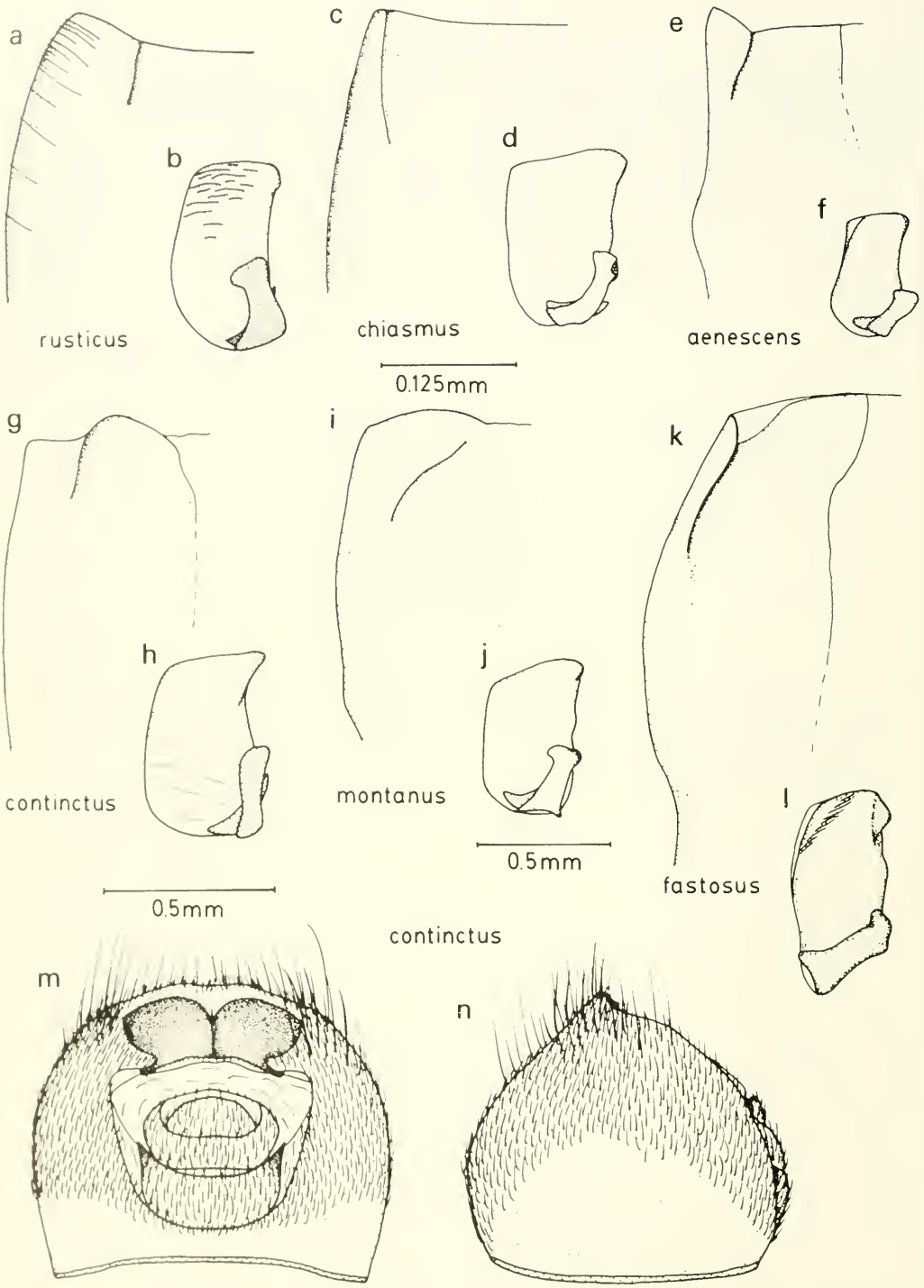


FIG. 48. *Arocatus* spp. a-l. Phallotheca of named species: a, c, e, g, i, k, dorsal view of left apex showing phallothecal process; b, d, f, h, j, l, lateral view. m, n. *A. continctus* Distant, pygophore: m, dorsal view; n, lateral view.

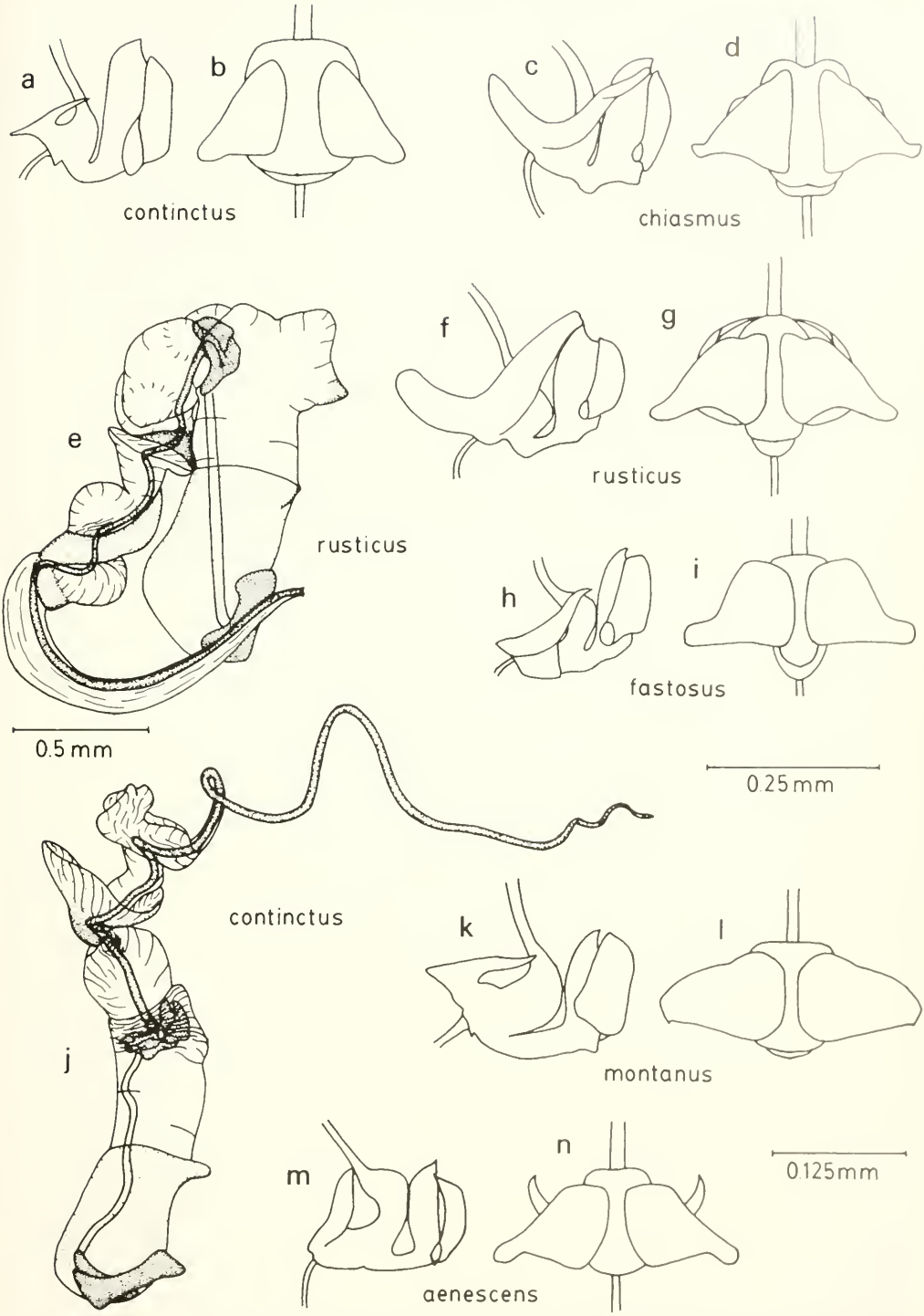


FIG. 49. *Arocatus* spp. a-d, f-i, k-n. Ejaculatory reservoir of named species: a, c, f, h, k, m, lateral view, b, d, g, i, l, n, dorsal view. e. *A. rusticus* (Stål), left lateral view of partially inflated aedeagus. j. *A. continctus* Distant, left lateral view of inflated aedeagus.

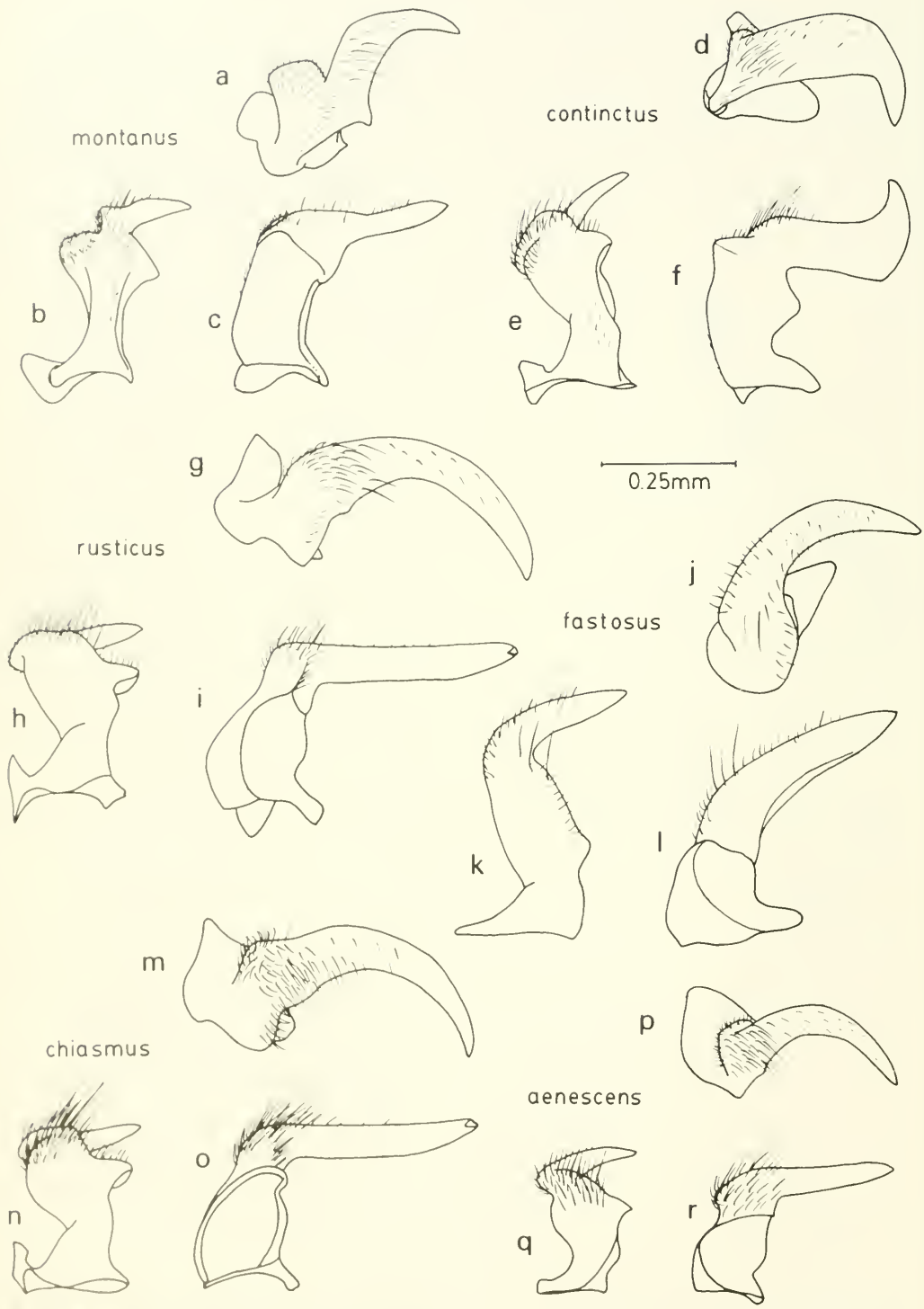


FIG. 50 *Arocatus* spp. a-r Left clasper of named species: a, d, g, j, m, p, dorsal view; b, e, h, k, n, q, posterior view; c, f, i, l, o, r, interolateral view.

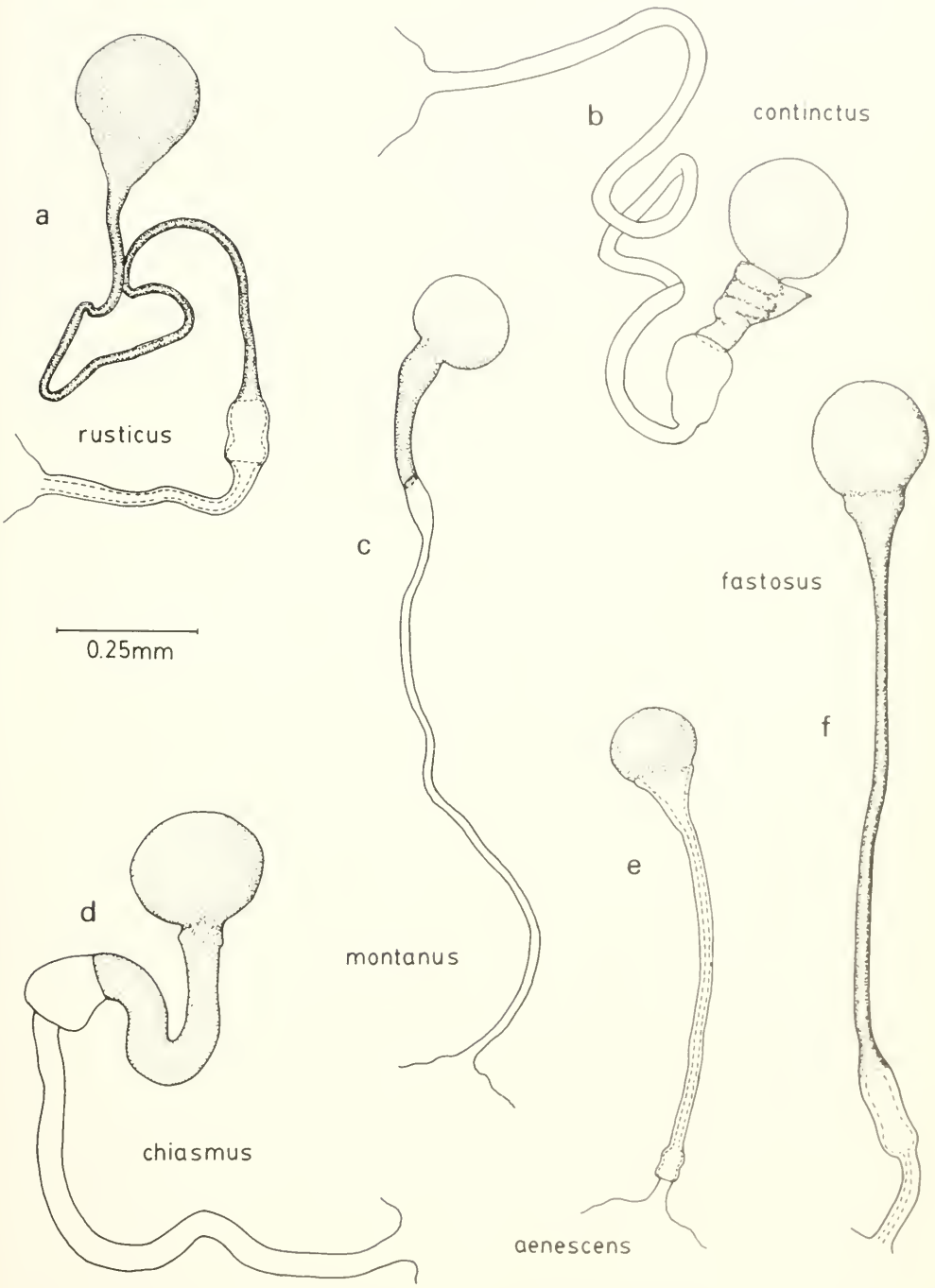


FIG. 51. *Arocatus* spp. a-f. Spermatheca of named species.

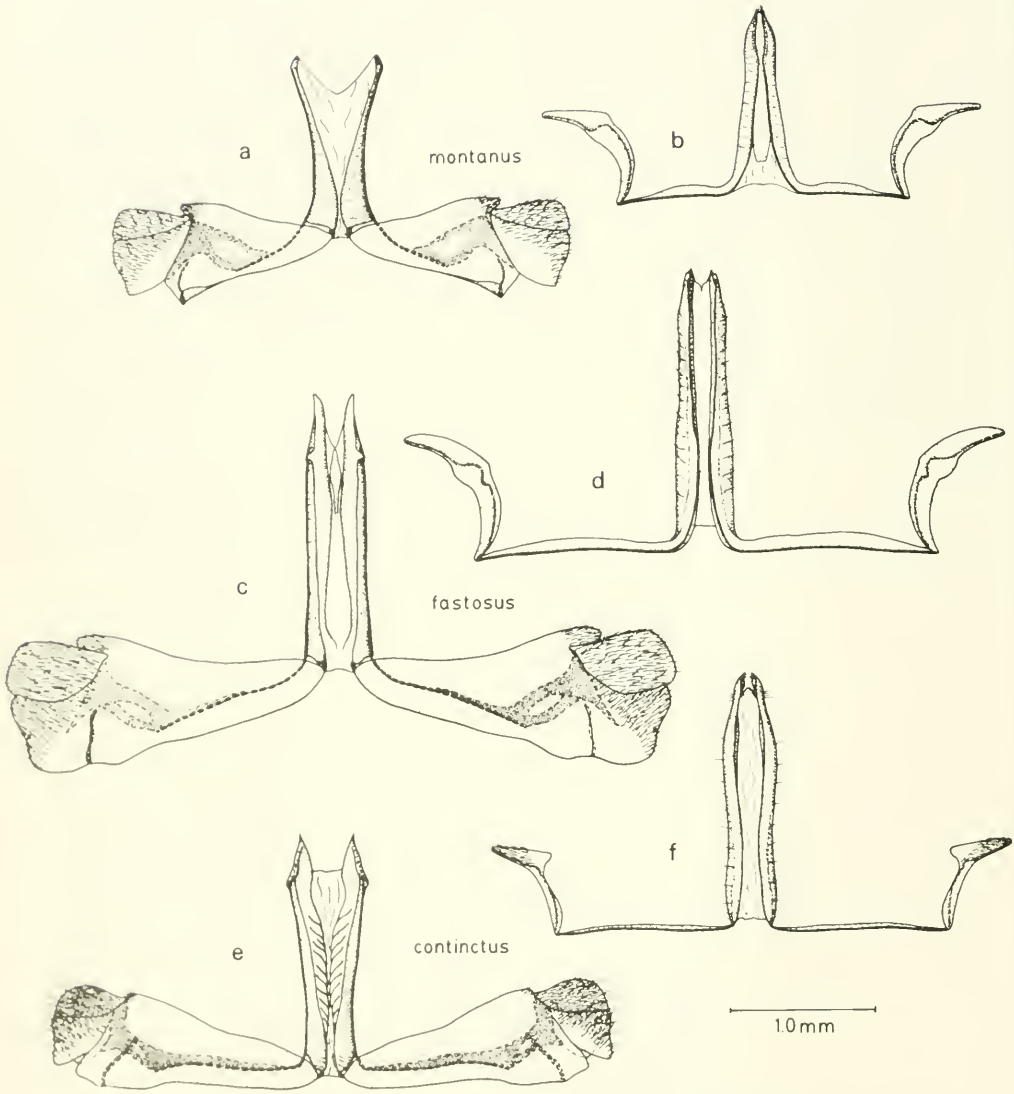


FIG. 52. *Arocatus* spp. a-f. Ovipositor of named species: a, c, e, first valve; b, d, f, second valve.

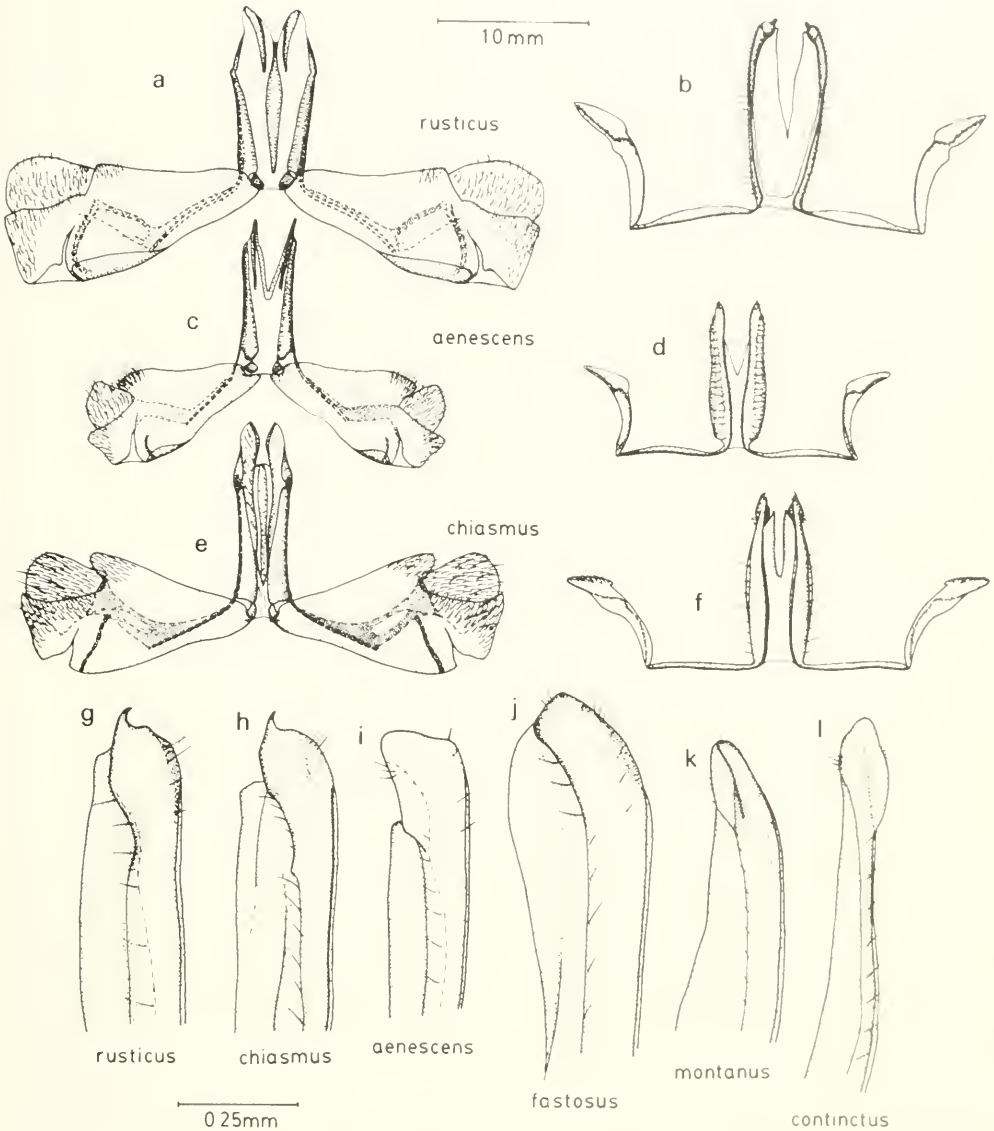


FIG. 53. *Arocatus* spp. a-l. Ovipositor of named species: a, c, e, first valve; b, d, f, second valve, g-l, apex of second valvula, lateral view.

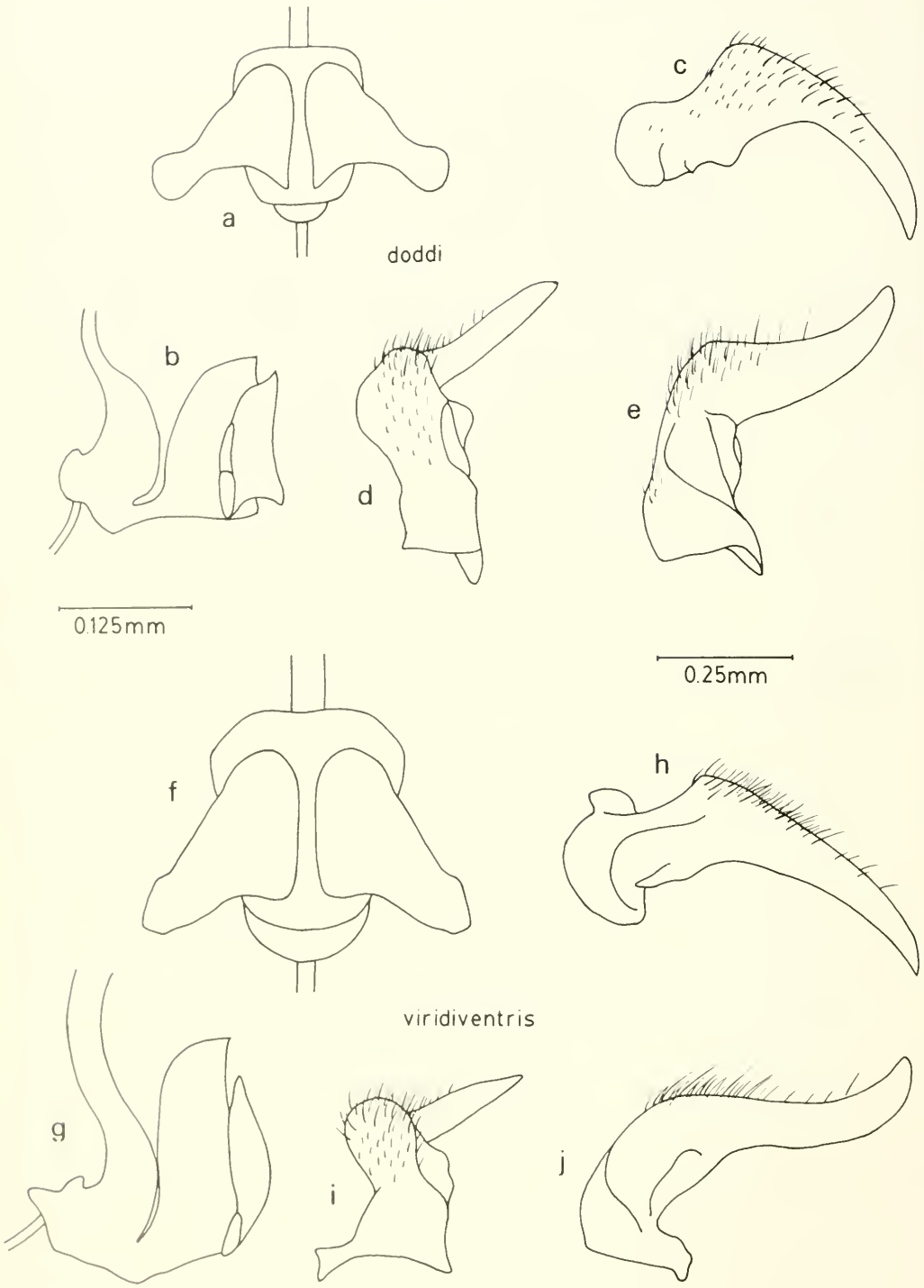


FIG. 54. *Astacops* spp. a, b, f, g. Ejaculatory reservoir of named species: a, f, dorsal view; b, g, lateral view. c-e, h-j. Left clasper of named species: c, h, dorsal view; d, i, posterior view; e, j, interolateral view.

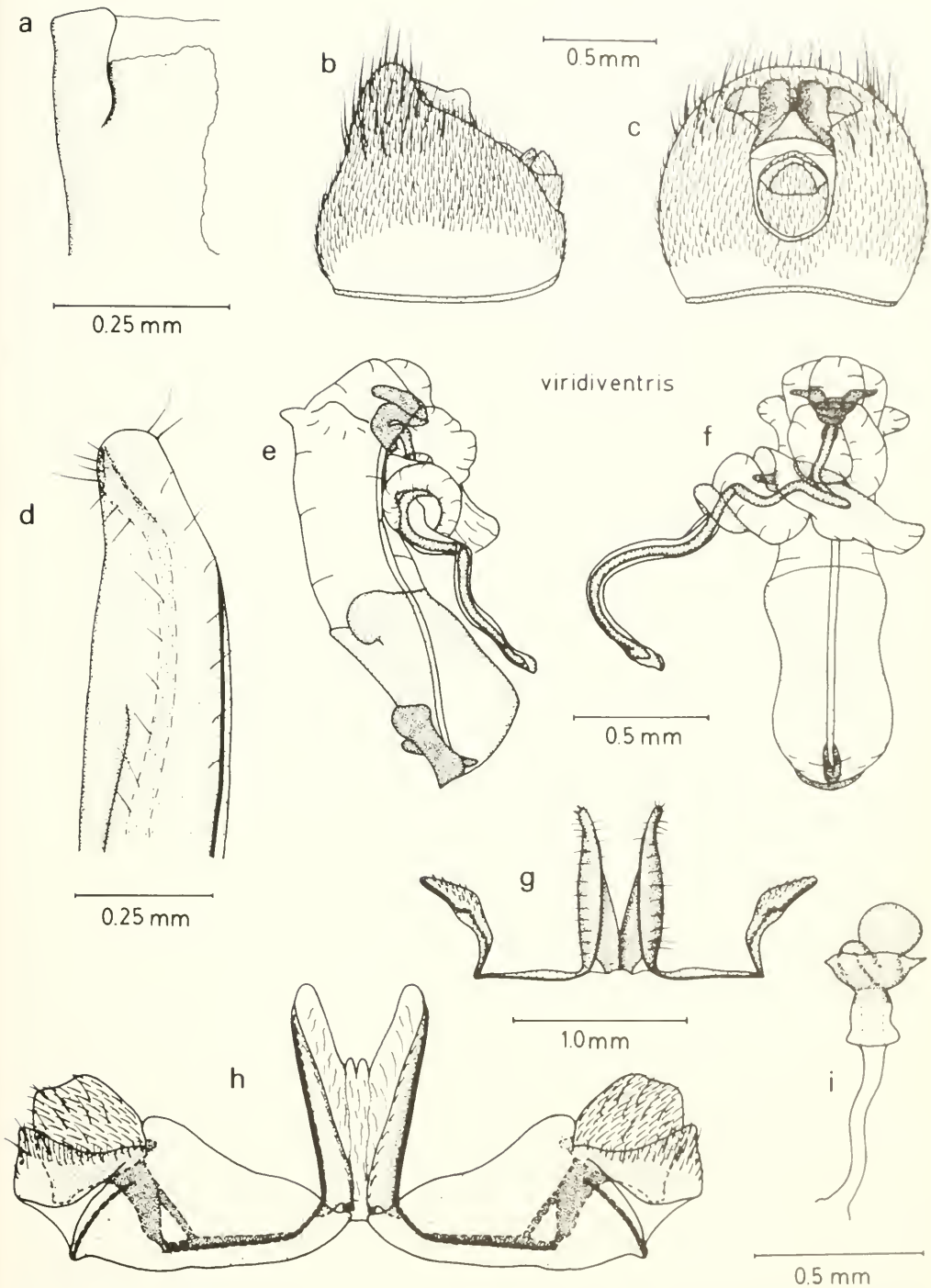


FIG. 55. *Astacops viridiventris* Stål. a. Phallotheca, dorsal view of left apex showing phallotheceal process. b, c Pygophore: b, lateral view; c, dorsal view. d. Apex of left second valvula, lateral view. e, f. Inflated aedeagus. e, right lateral view; f, ventral view. g, h. Ovipositor: g, second valve; h, first valve. i. Spermatheca

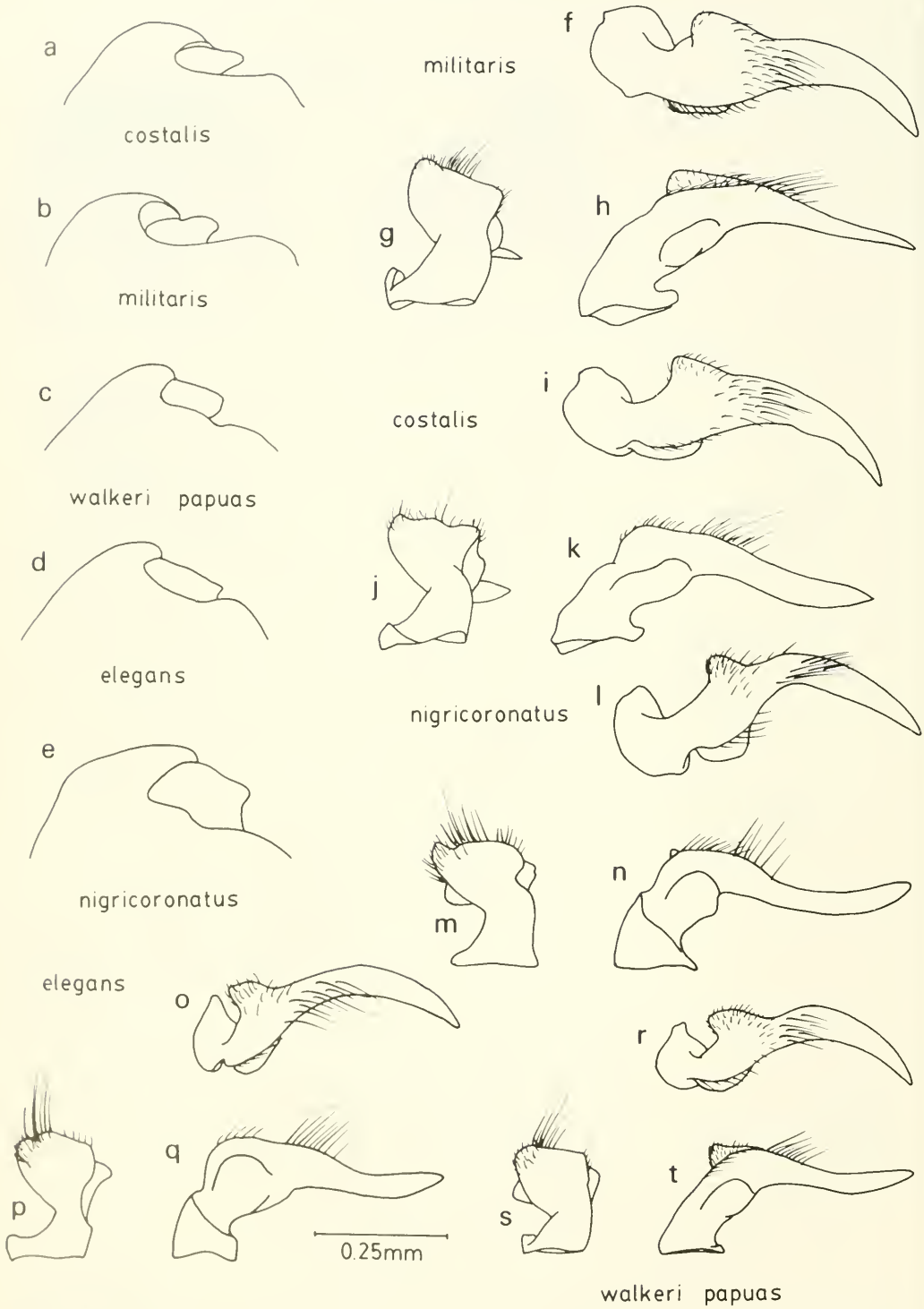


FIG. 56 *Scopiastella* spp. a-e. Apex of pygophore of named species, lateral view. f-t. Left clasper of named species: f, i, l, o, r, dorsal view; g, j, m, p, s, posterior view; h, k, n, q, t, interolateral view.

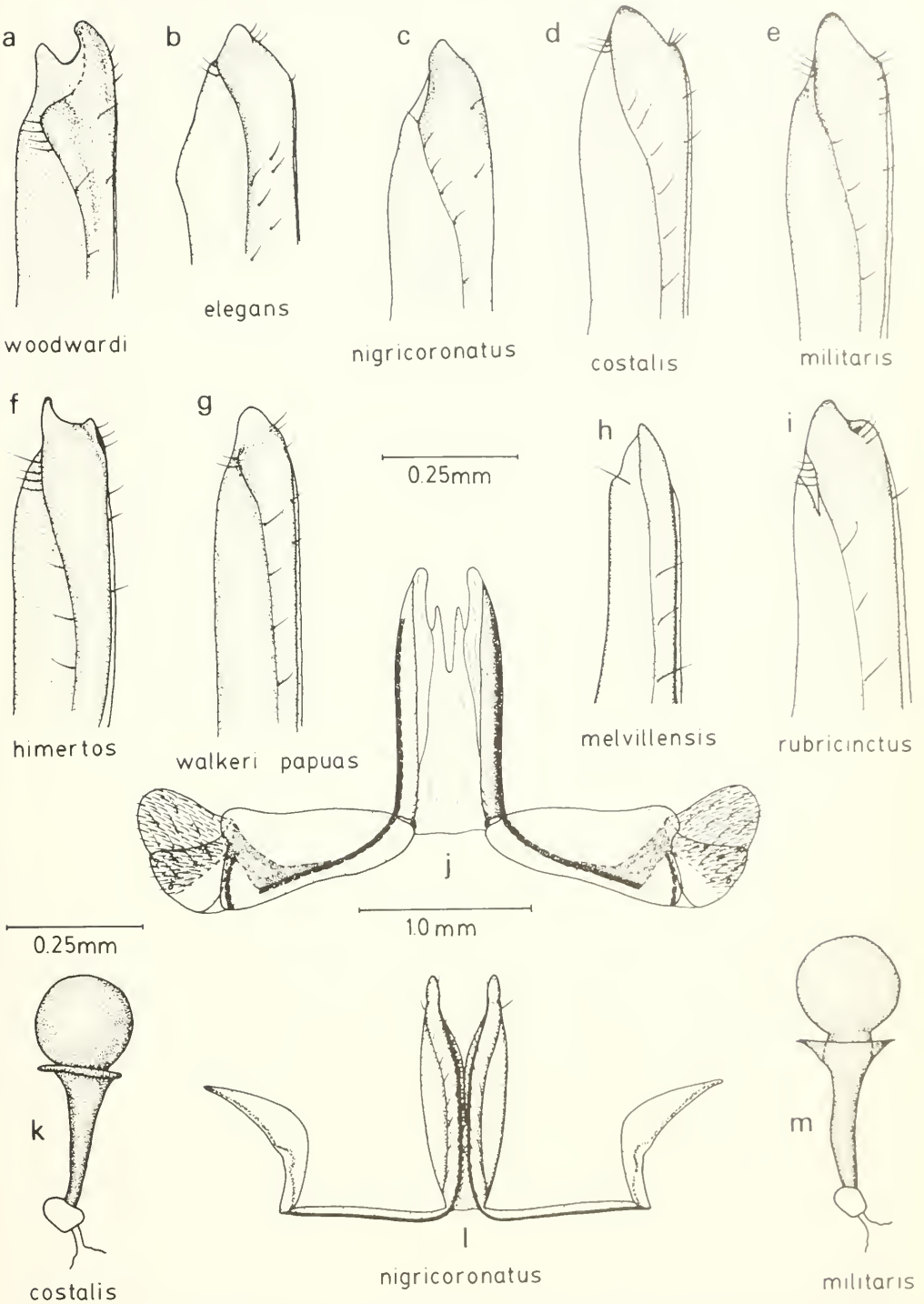


FIG. 57. *Scopiastella* spp. a-i. Apex of left second valvula of named species, lateral view. j, l. *S. nigricoronatus*, sp. nov., ovipositor: j, first valve; l, second valve. k, m. Spermatheca of named species

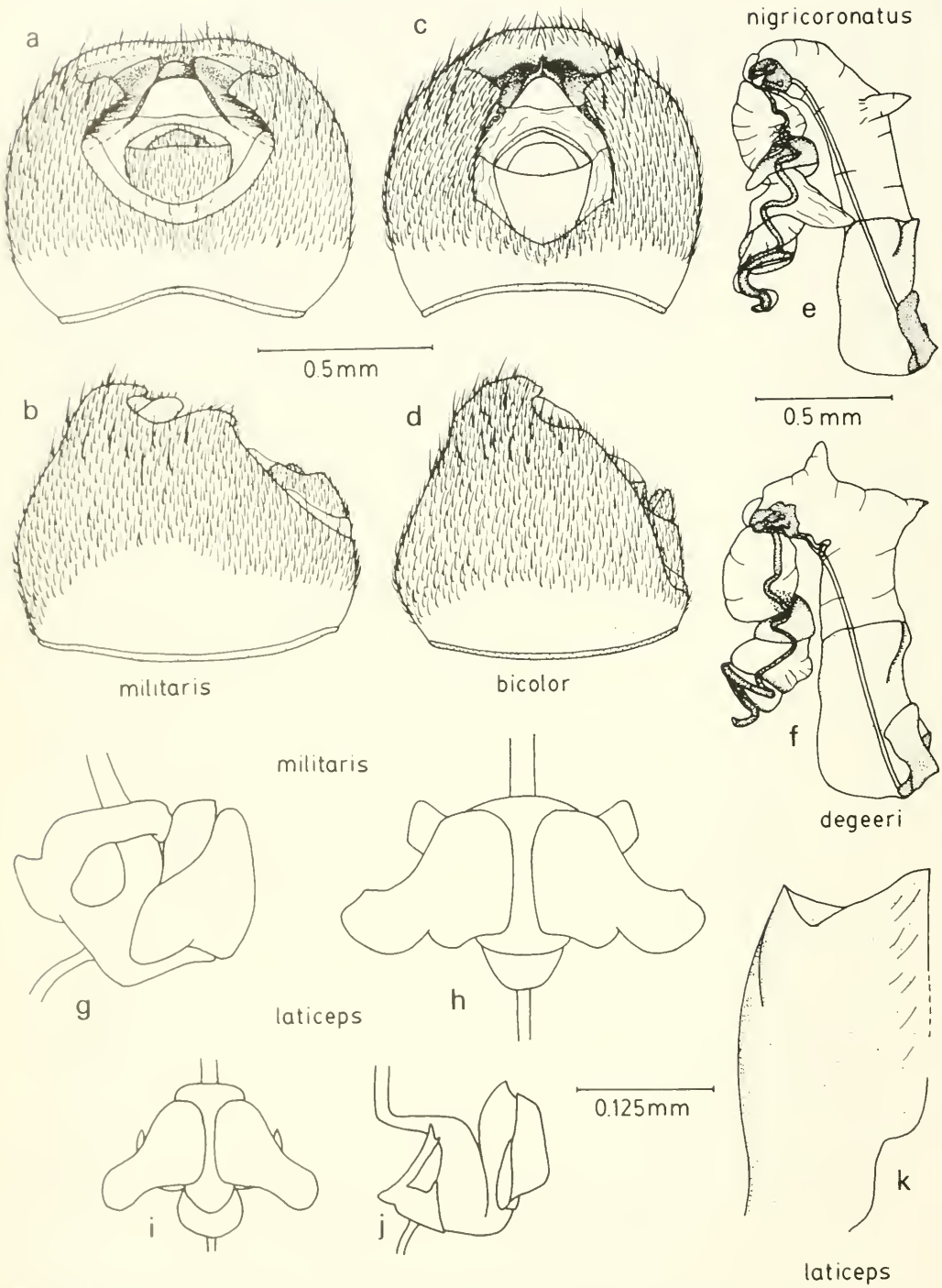


FIG. 58. a, b, e, g, h. *Scopiastella* spp. a, b. *S. militaris* (Distant), pygophore: a, dorsal view; b, lateral view. e. *S. nigricoronatus*, sp. nov., partially inflated aedeagus, left lateral view. g, h. *S. militaris* (Distant), ejaculatory reservoir: g, lateral view, h, dorsal view. c, d, f, i, j, k. *Scopiastes* spp. c, d. *S. bicolor* Distant, pygophore: c, dorsal view; d, lateral view. f. *S. degeeri* (Stål), partially inflated aedeagus, left lateral view. i-k. *S. laticeps* Breddin. i, j. Ejaculatory reservoir: i, dorsal view; j, lateral view. k. Phallotheca, dorsal view of left apex showing phallothecal process.

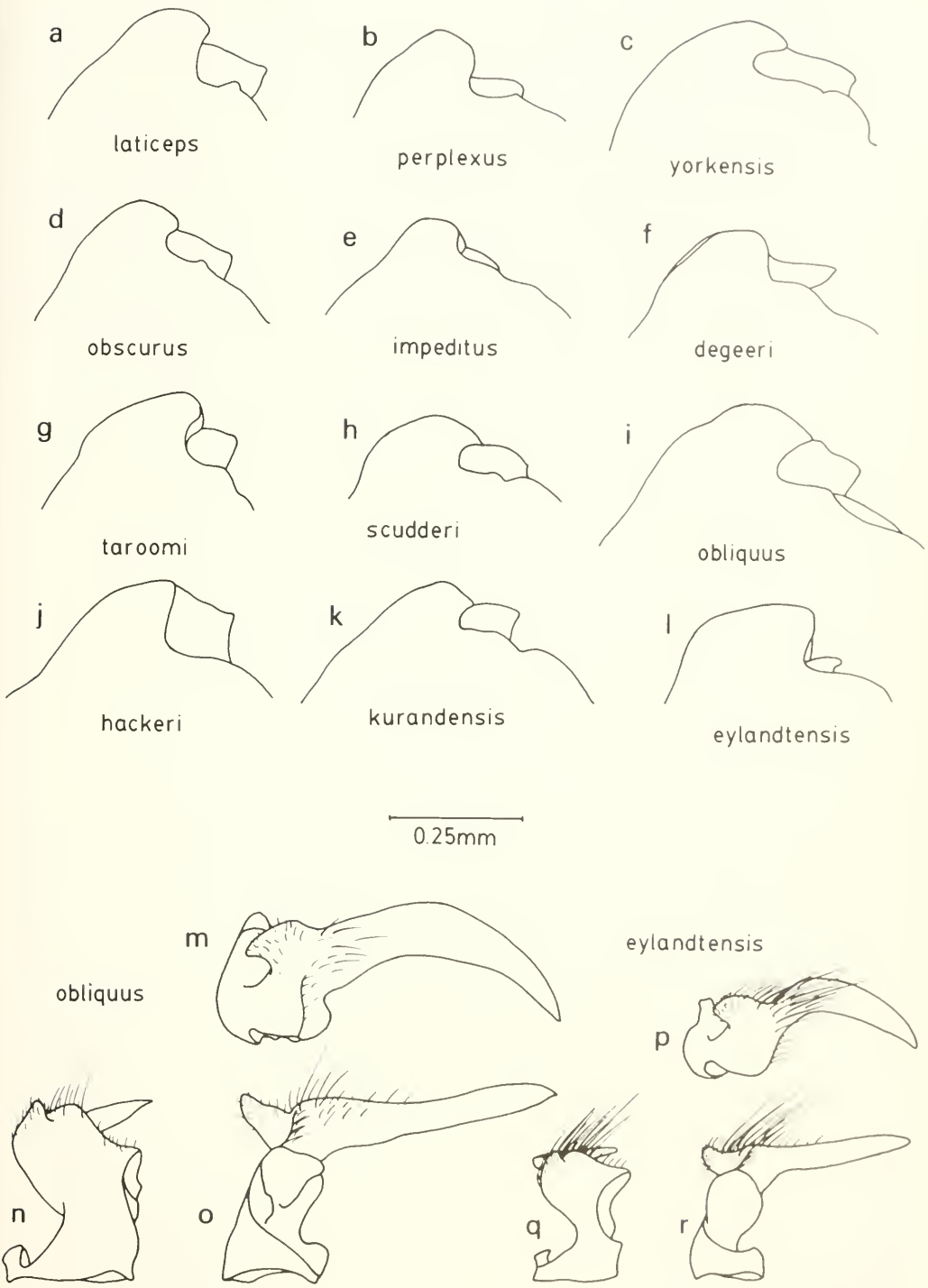


FIG. 59. *Scopiastes* spp. a-l. Apex of pygophore of named species, lateral view. m-r Left clasper of named species. m, p, dorsal view; n, q, posterior view; o, r, interolateral view.

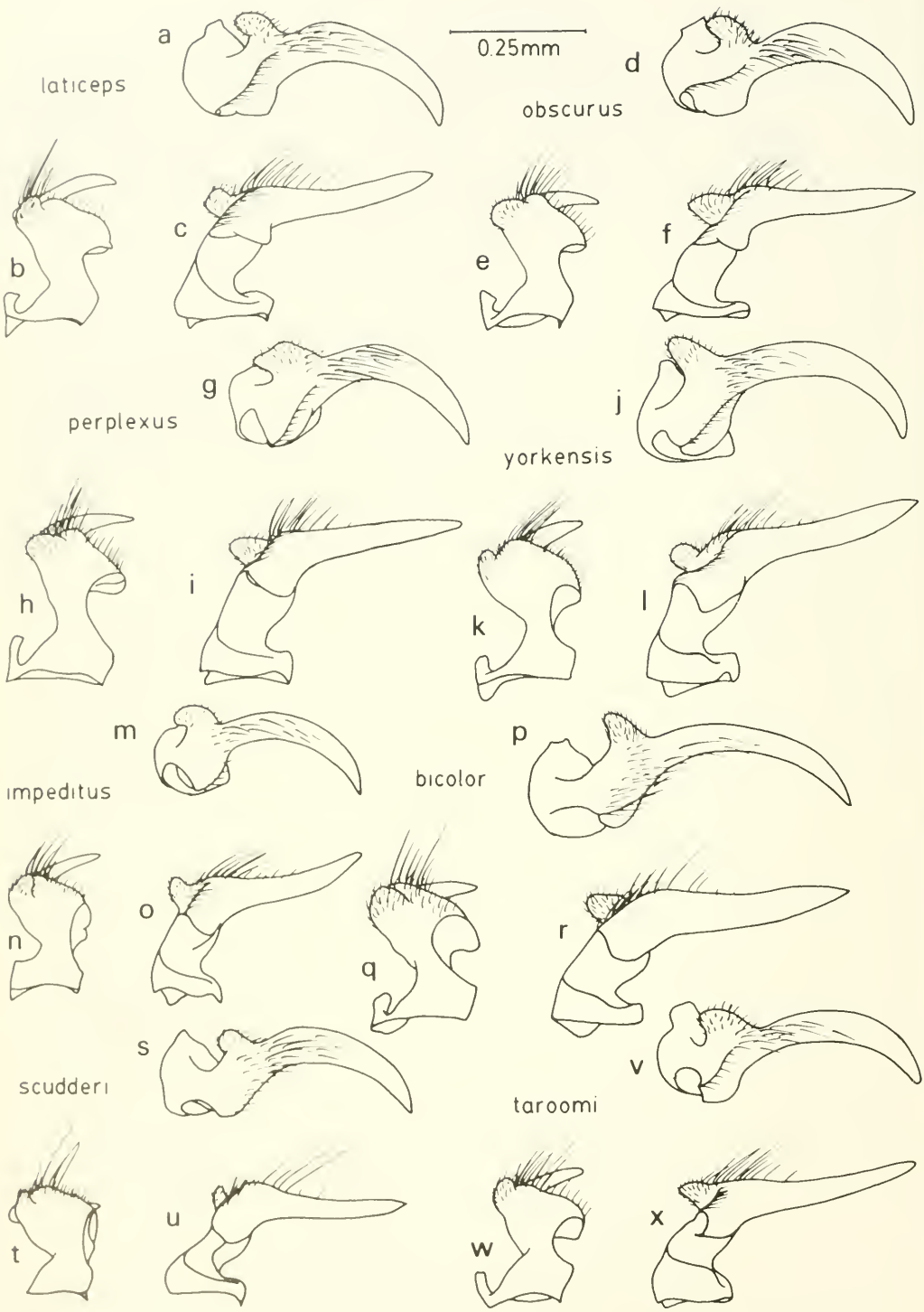


FIG. 60. *Scoptastes* spp. a-x. left clasper of named species: a, d, g, j, m, p, s, v, dorsal view; b, e, h, k, n, q, t, w, posterior view; c, f, i, l, o, r, u, x, interolateral view.

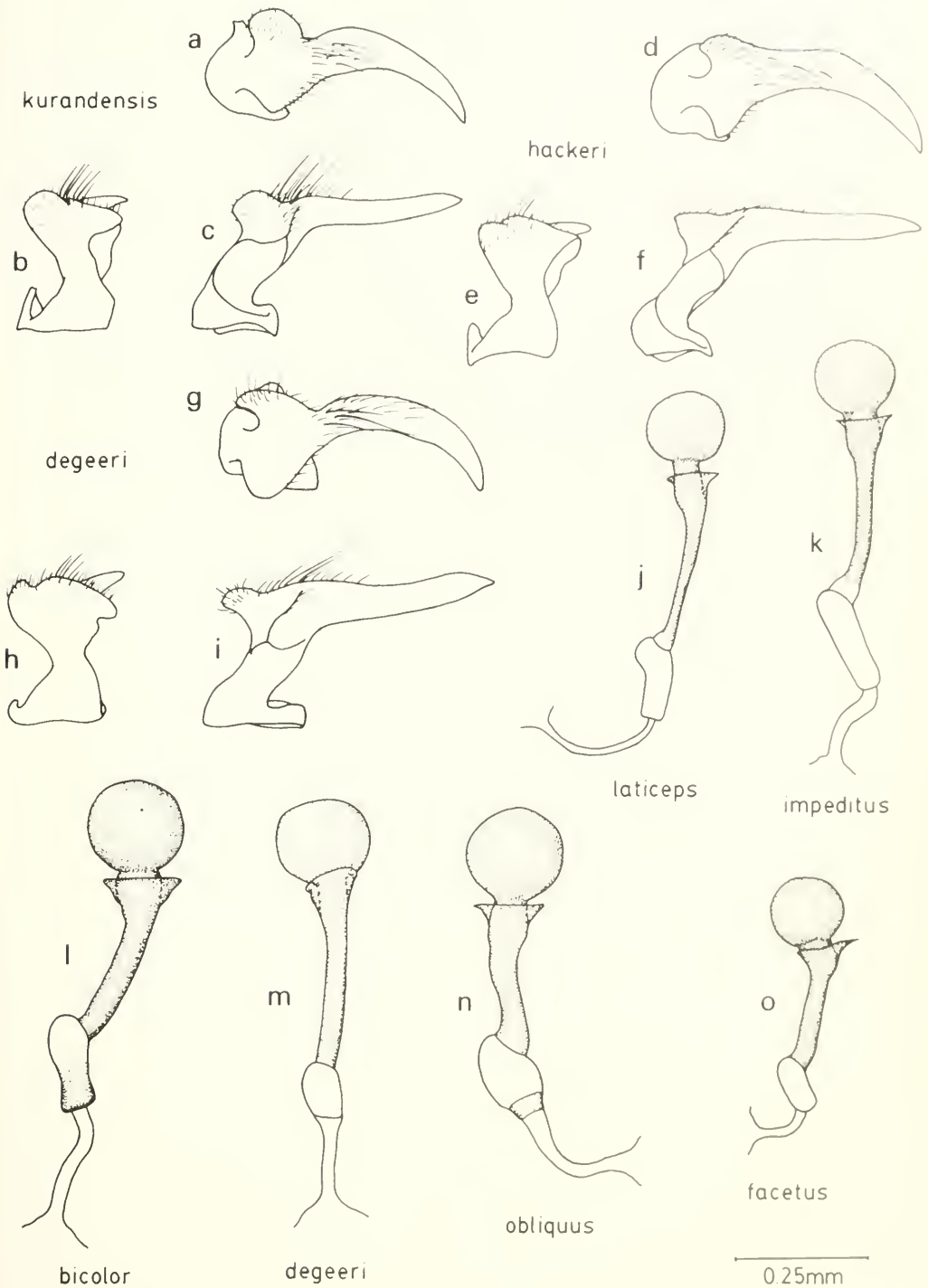


FIG. 61. *Scopiastes* spp. a-i. Left clasper of named species: a, d, g, dorsal view, b, e, h, posterior view, c, f, i interolateral view. j-o. Spermatheca of named species

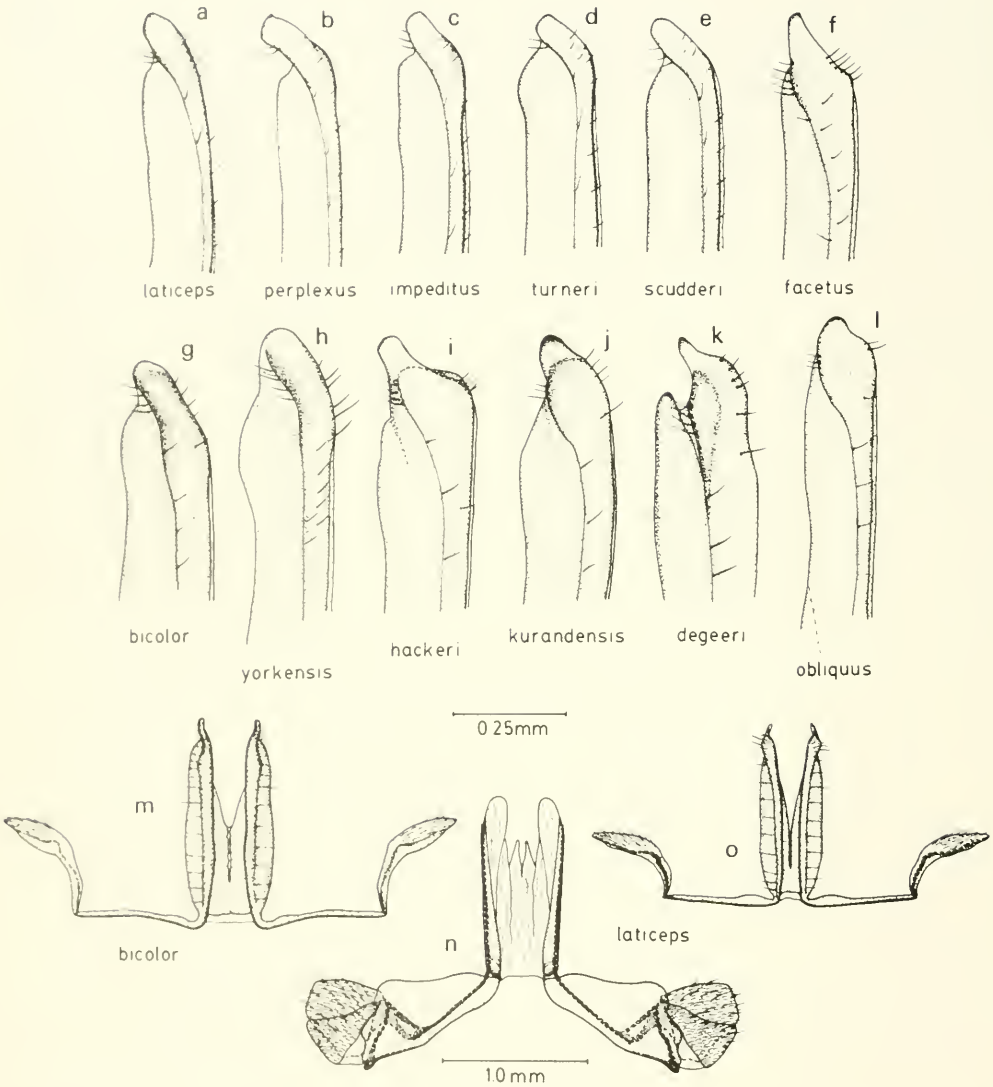


FIG. 62. *Scopiastes* spp. a-l. Apex of left second valvula of named species, lateral view. m-o. Ovipositor of named species: m, o, second valve; n, first valve.

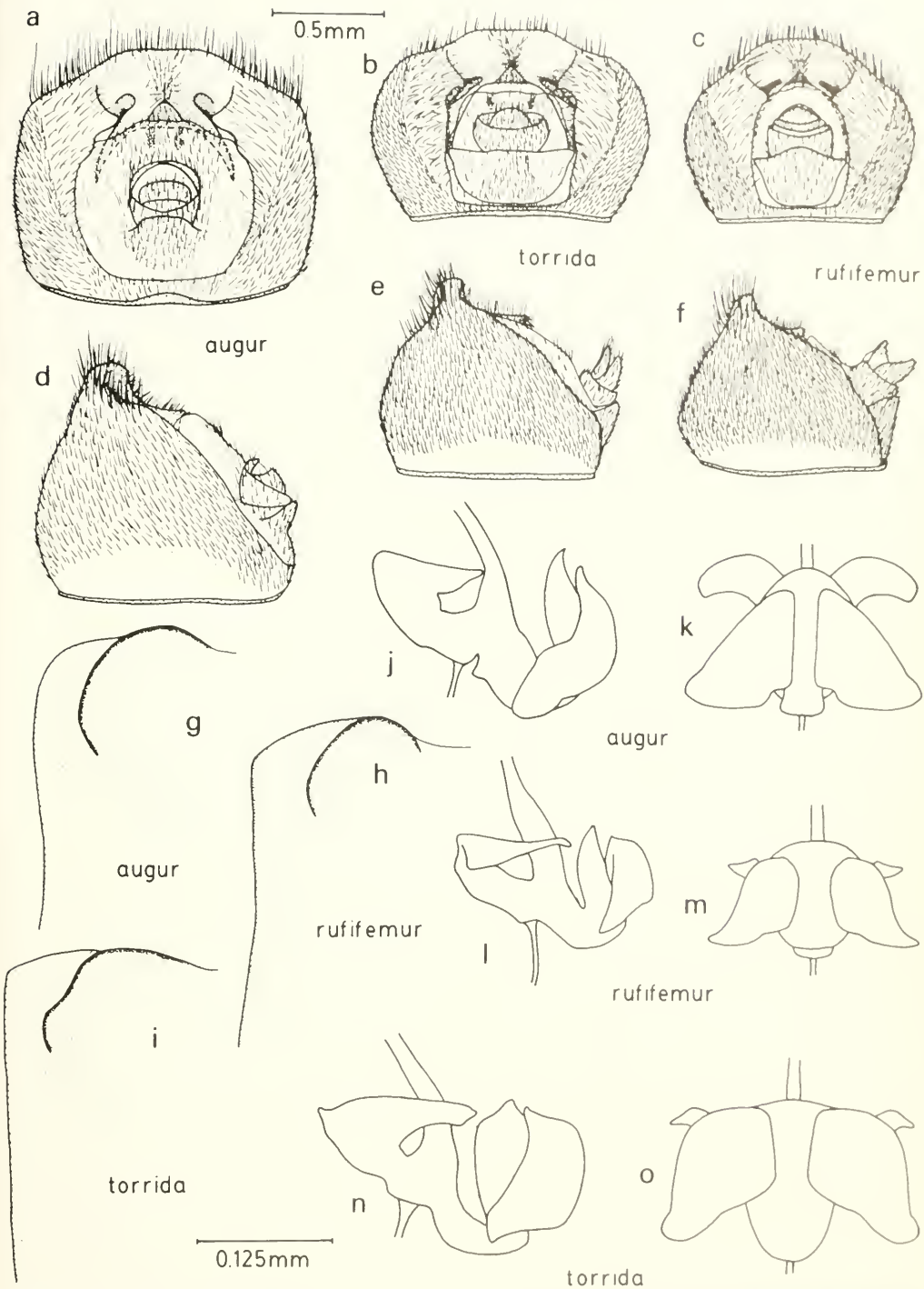


FIG. 63. *Thunbergia* spp. a-f. Pygophore of named species: a-c, dorsal view, d-f, lateral view. g-i. Phallotheca of named species, dorsal view of left apex showing phallothecal process. l-o. Ejaculatory reservoir of named species: l, n, lateral view; m, o, dorsal view.

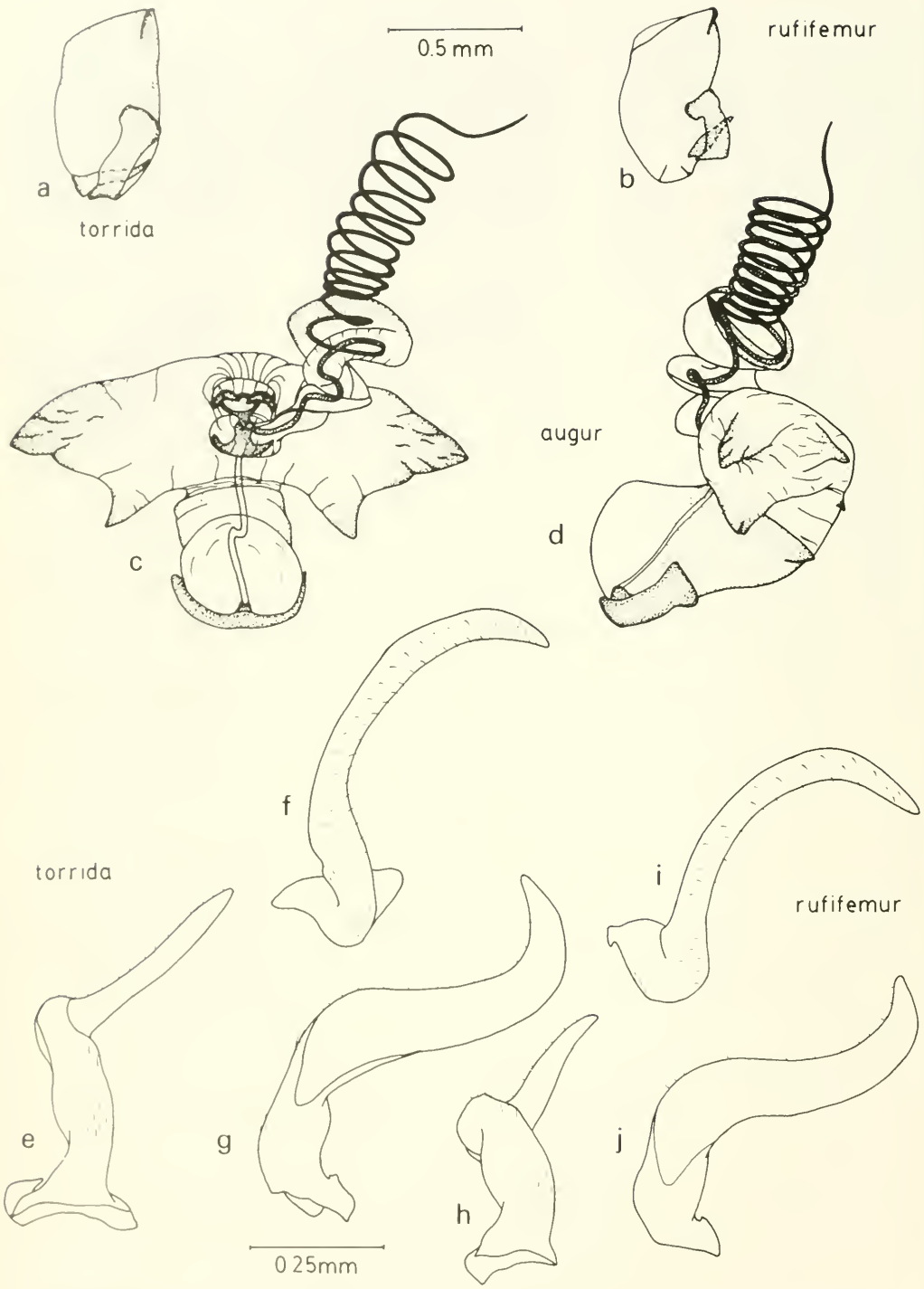


FIG. 64. *Thunbergia* spp. a, b. Phallotheca of named species, lateral view. c, d. *T. augur* (Stål), inflated aedeagus: c, ventral view, d, left lateral view. e-j. Left clasper of named species: e, h, posterior view; f, i, dorsal view; g, j, interolateral view.

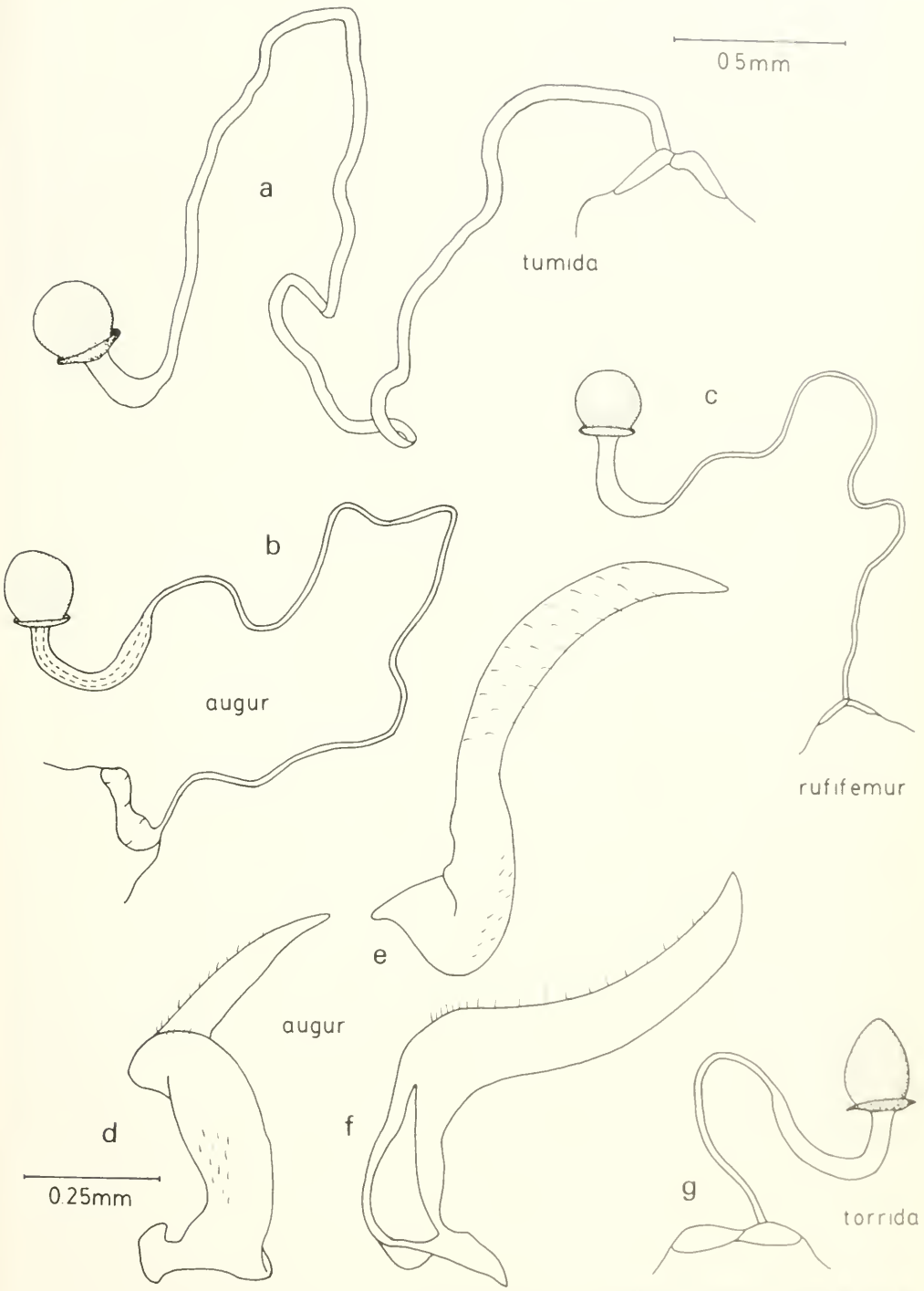


FIG. 65. *Thunbergia* spp. a-c, g. Spermatheca of named species. d-f. *T. augur* (Stål), left clasper: d, posterior view; e, dorsal view; f, interolateral view

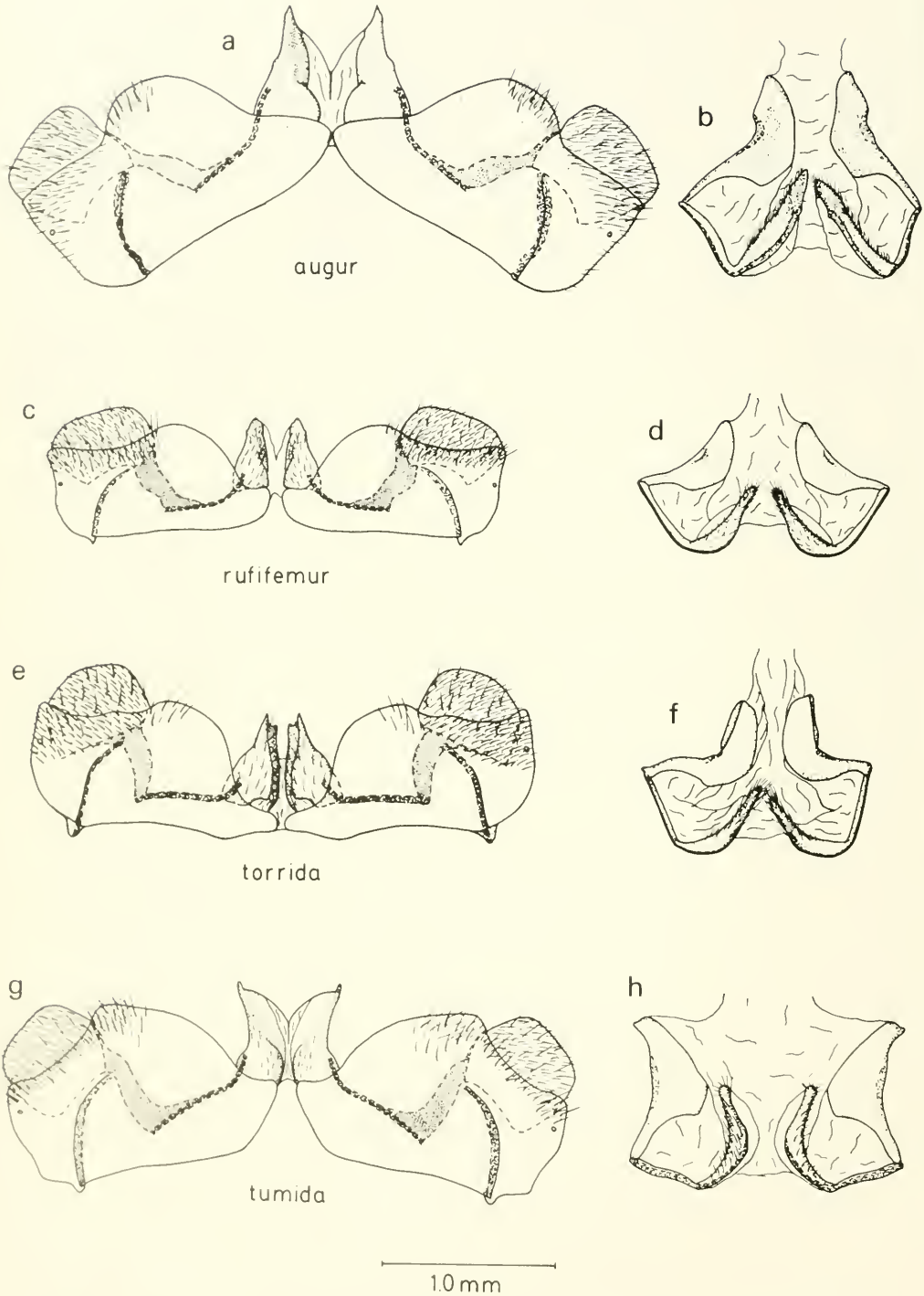


FIG. 66. *Thunbergia* spp. a-h. Ovipositor of named species: a, c, e, g, first valve; b, d, f, h, second valve.

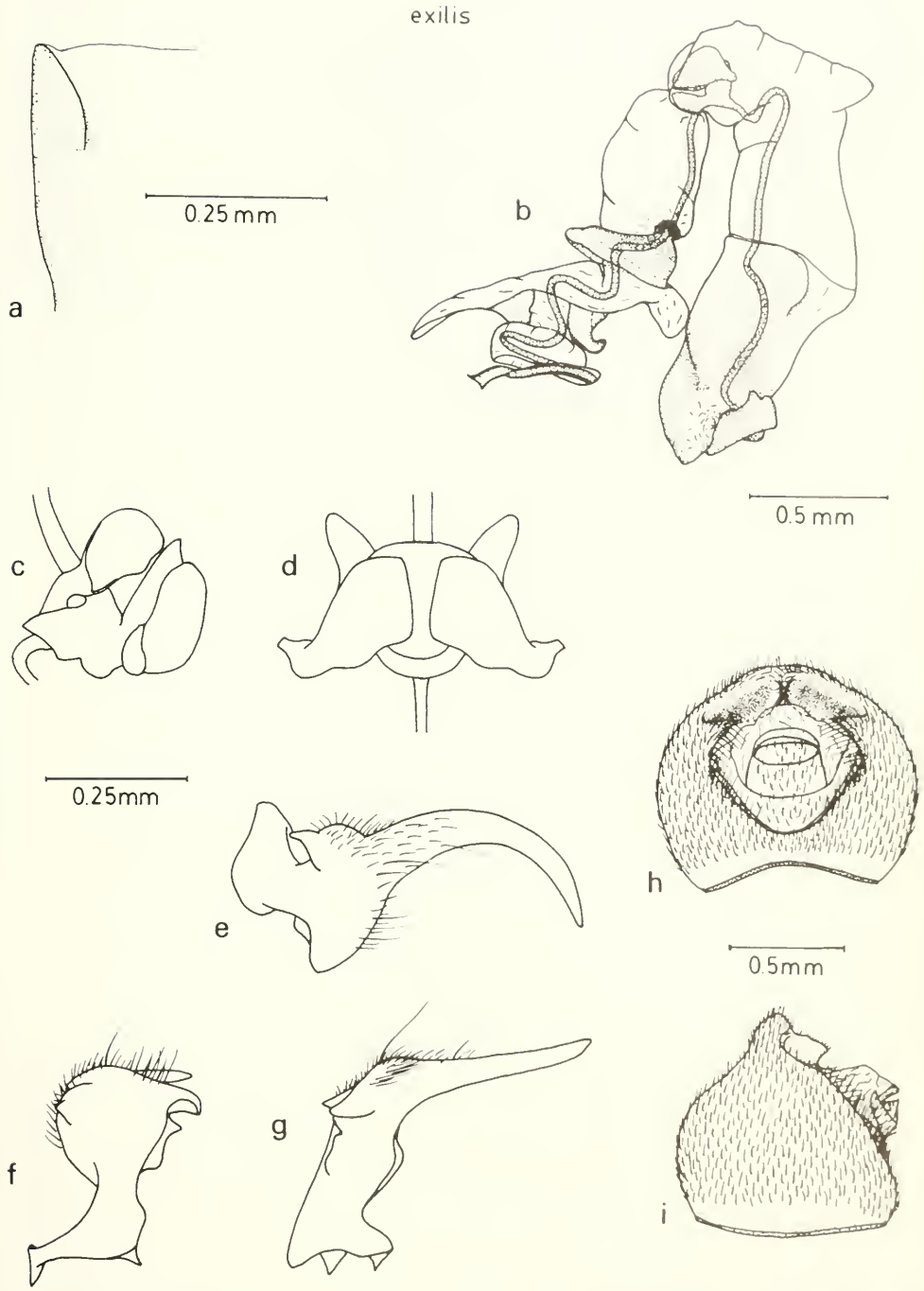


FIG. 67. *Woodwardiastes exilis,* sp. nov. a. Phallotheca, dorsal view of left apex showing phallotheca process. b. Partially inflated aedeagus, left lateral view. c, d. Ejaculatory reservoir: c, lateral view; d, dorsal view. e-g. Left clasper: e, dorsal view; f, posterior view; g, interolateral view. h, i. Pygophore: h, dorsal view, i, lateral view.

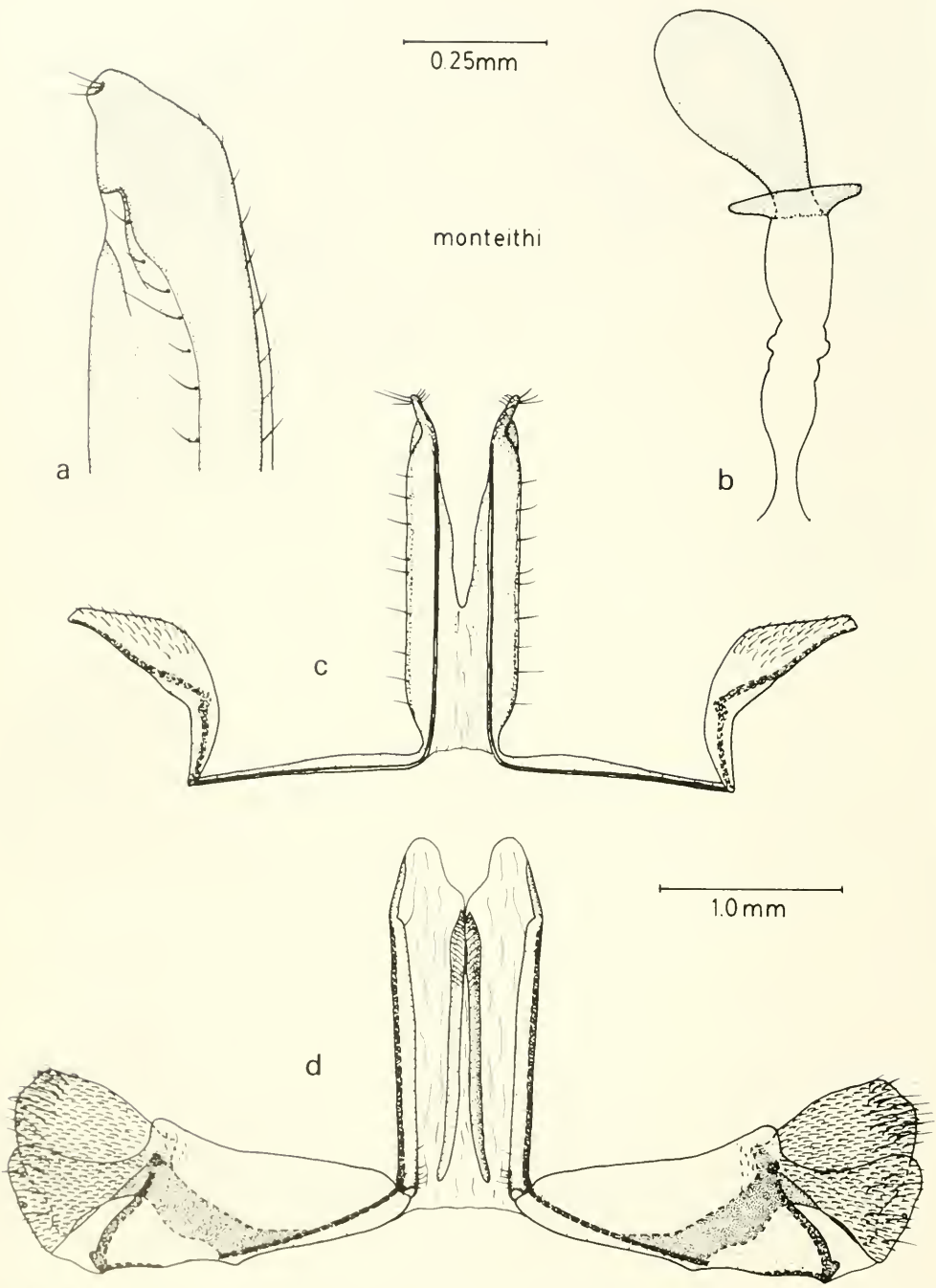


FIG. 68 *Woodwardiastes monteithi*, sp. nov. a, c, d. Ovipositor: a, apex of left second valvula, lateral view; c, second valve; d, first valve. b. Spermatheca.

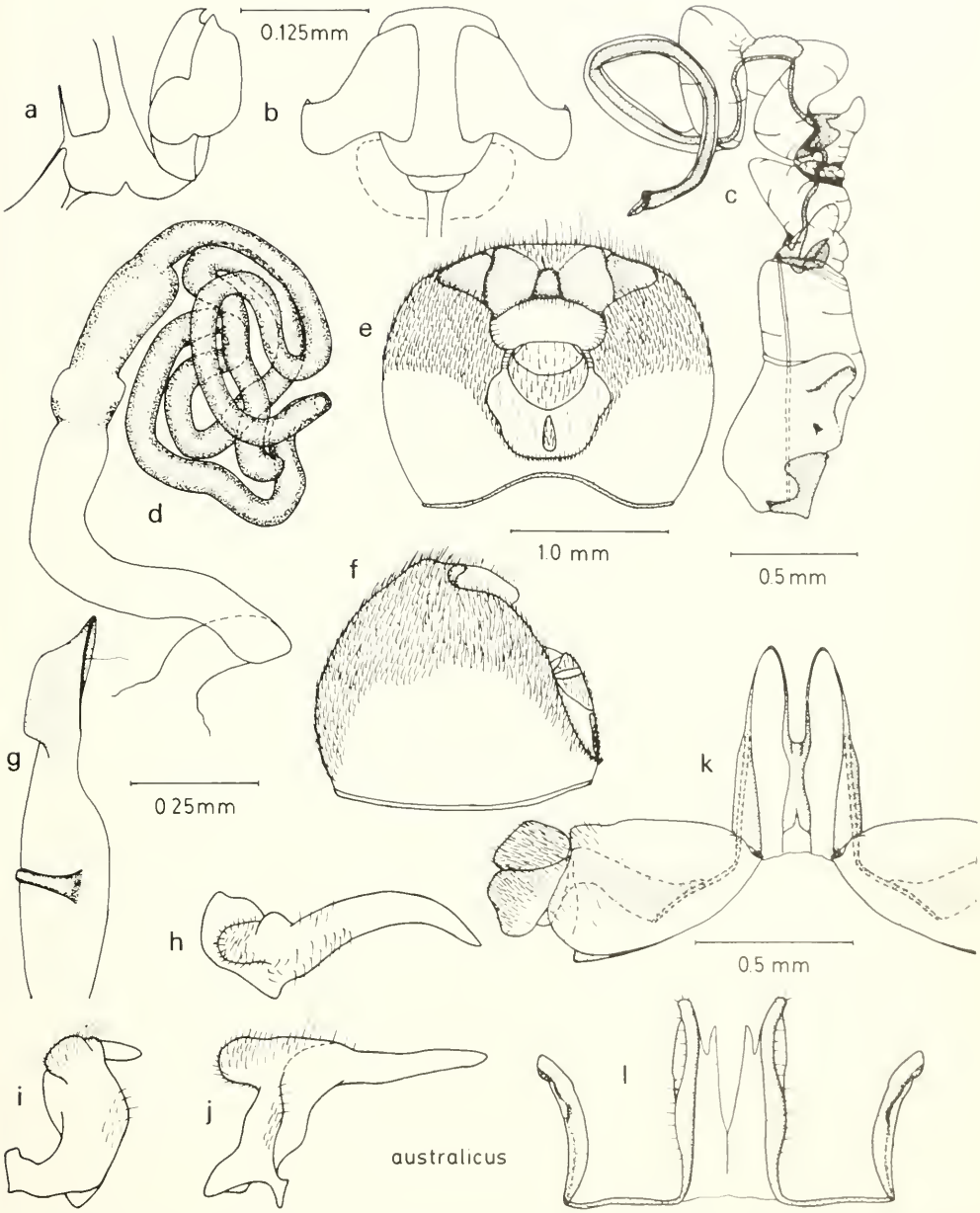


FIG. 69. *Aspilocoryphus australicus* Stål. a, b. Ejaculatory reservoir: a, lateral view; b, dorsal view. c. Partially inflated aedeagus, left lateral view. d. Spermatheca. e, f. Pygophore: e, dorsal view; f, lateral view. g. Phallotheca, dorsal view of left apex showing phallothecal process. h-j. Left clasper: h, dorsal view; i, posterior view; j, interolateral view. k, l. Ovipositor: k, first valve; l, lateral view.

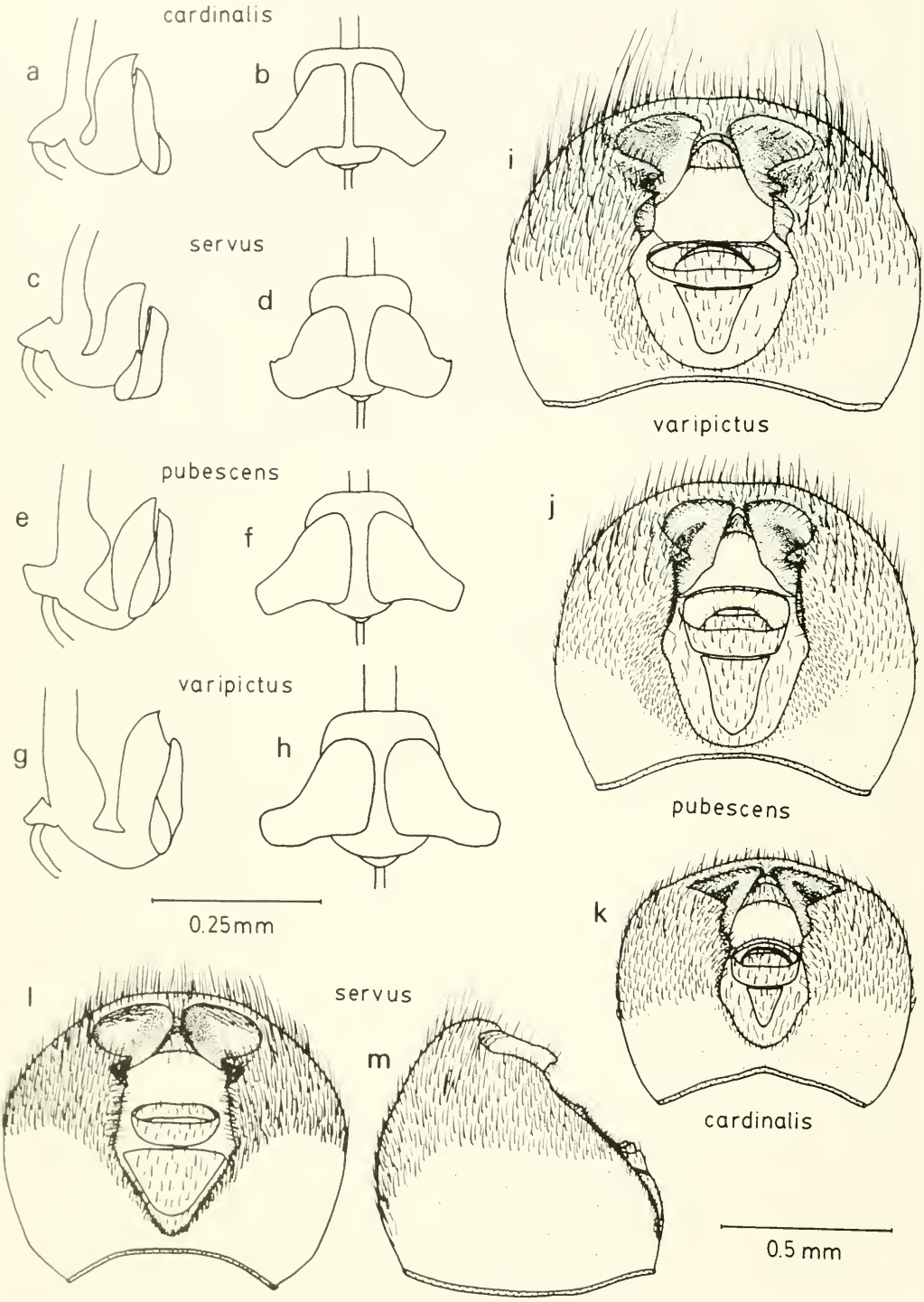


FIG. 70. *Graptostethus* spp. a-h. Ejaculatory reservoir of named species: a, c, e, g, lateral view; b, d, f, h, dorsal view. i-m. Pygophore of named species: i-l, dorsal view; m, lateral view.

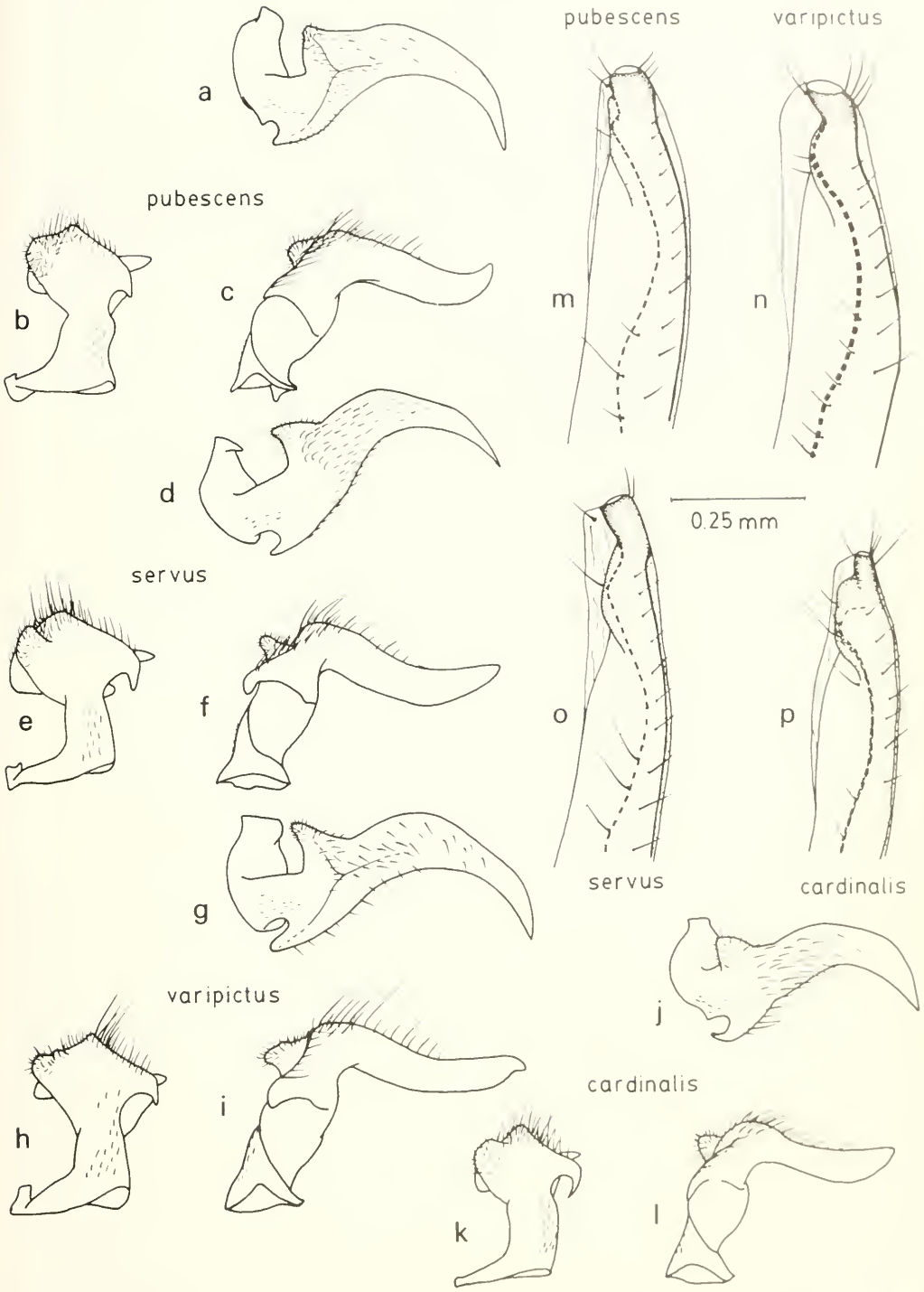


FIG. 71. *Graptostethus* spp. a-l. Left clasper of named species: a, d, g, j, dorsal view, b, e, h, k, posterior view, c, f, i, l, interolateral view. m-p. Apex of left second valvula of named species, lateral view.

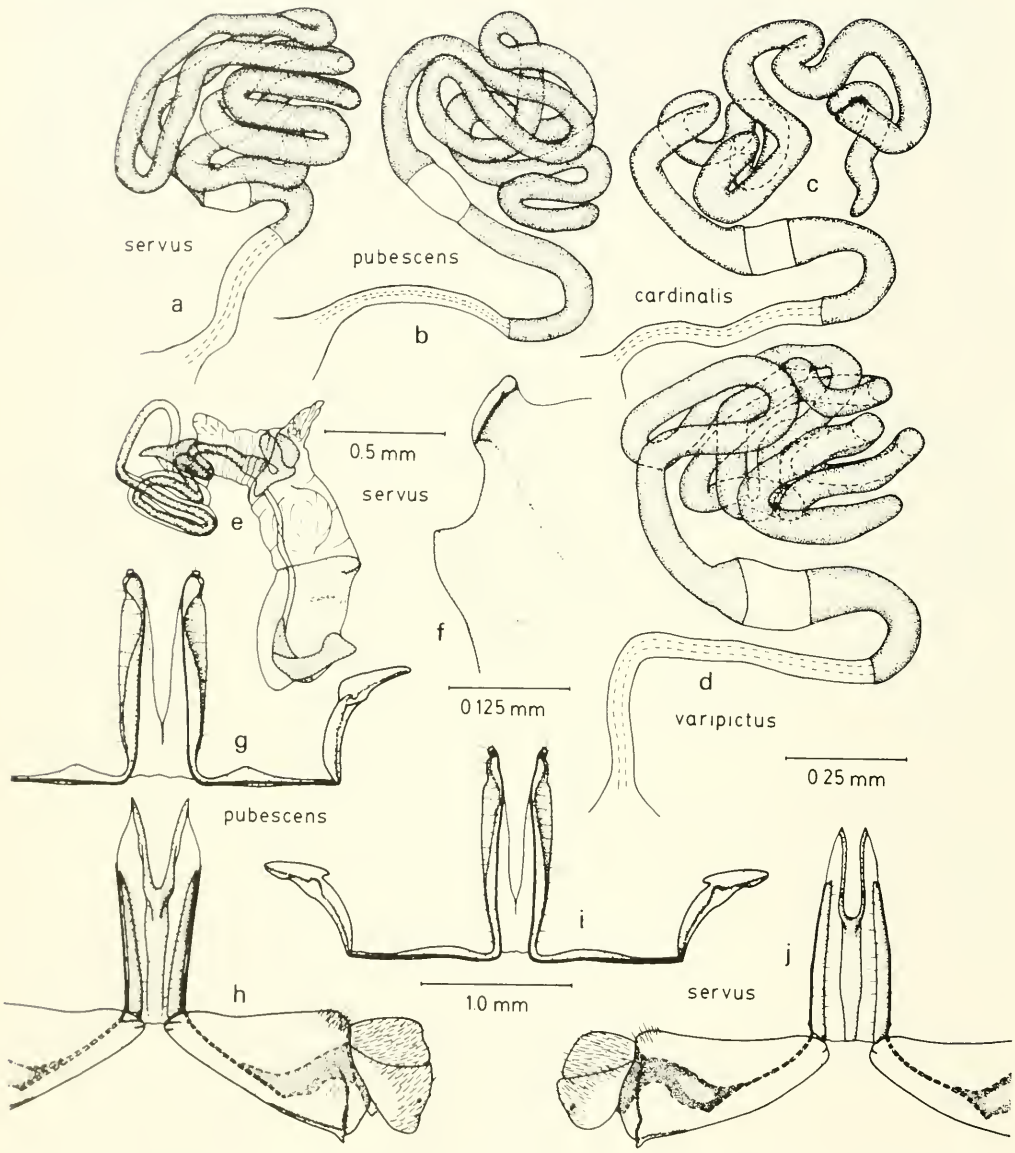


FIG. 72. *Graptostethus* spp. a-d. Spermatheca of named species. i, j. *G. servus* (Fabricius): i, left lateral view of partially inflated aedeagus; j, phallotheca, dorsal view of left apex showing phallothecal process. g-j. Ovipositor of named species: g, i, second valve; h, j, first valve.

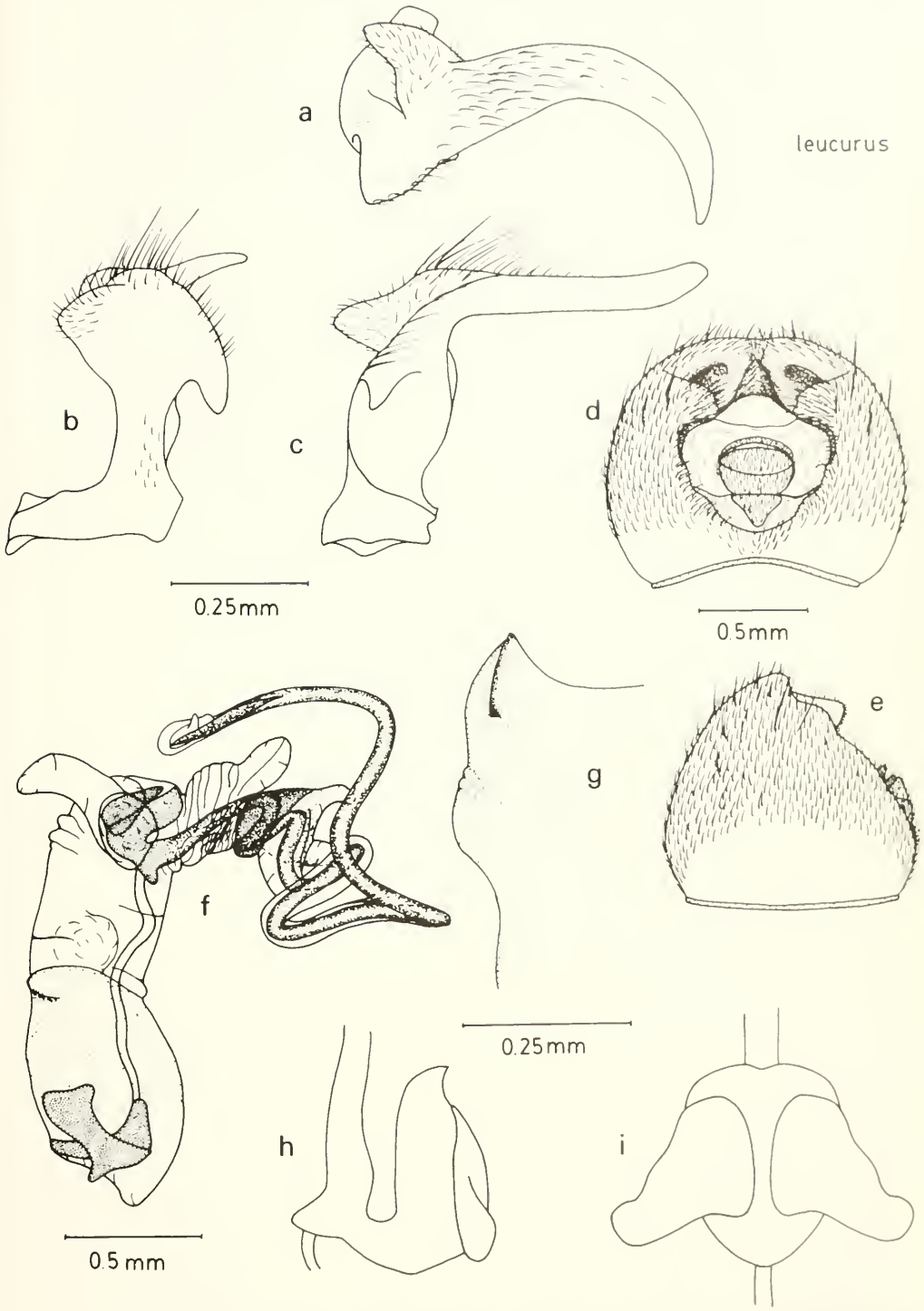


FIG. 73. *Pyrrhobaphus leucurus* (Fabricius). a-c. Left clasper: a, dorsal view; b, posterior view; c, interolateral view. d, e. Pygophore: d, dorsal view; e, lateral view. f. Partially inflated aedeagus, right lateral view. g. Phallotheca, dorsal view of left apex showing phallothecal process. h, i. Ejaculatory reservoir: h, lateral view, i, dorsal view.

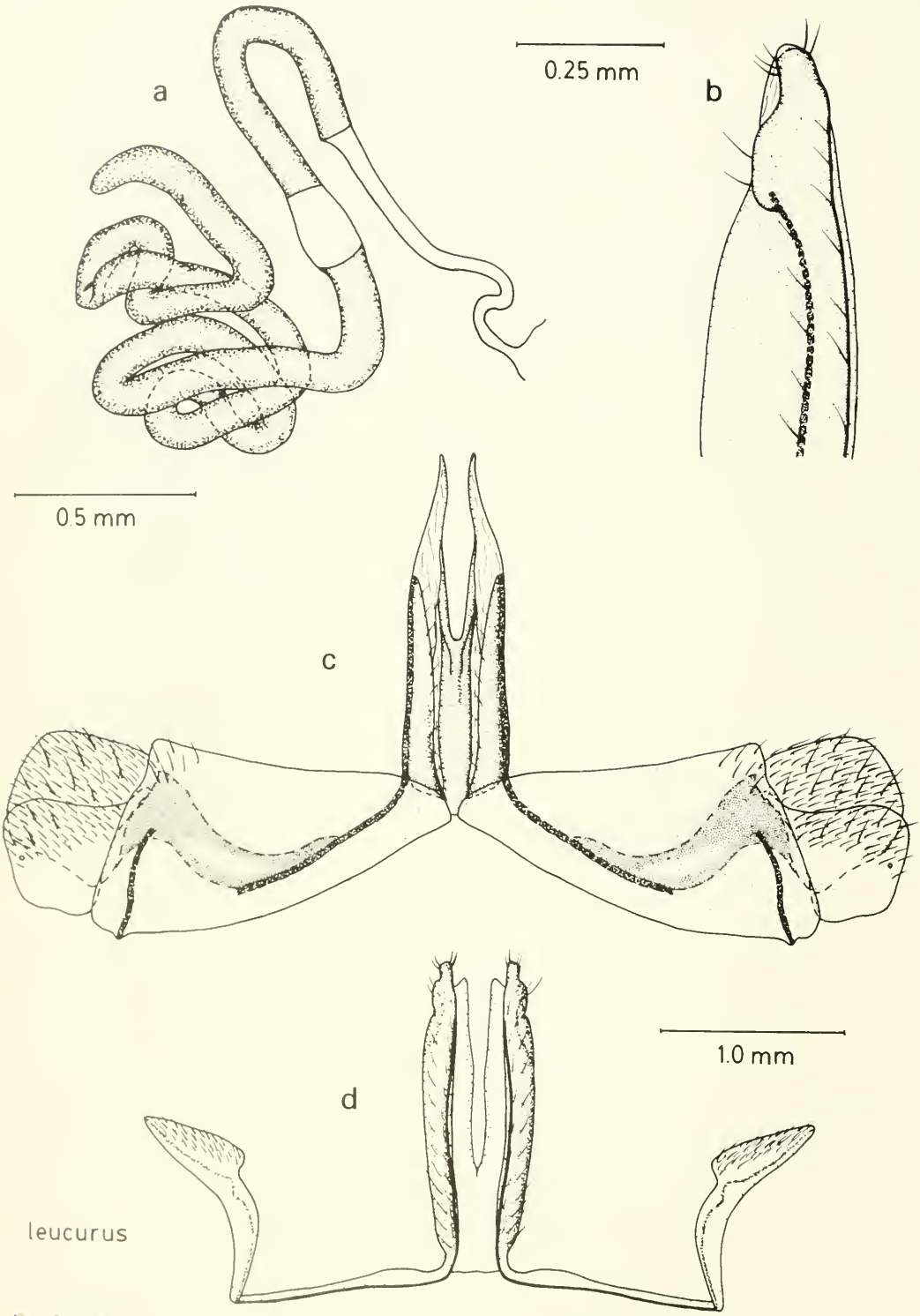


FIG. 74 *Pyrrhobaphus leucurus* (Fabricius). a. Spermatheca. b. Apex of left second valvula, lateral view. c, d. Ovipositor: c, first valve; d, second valve.

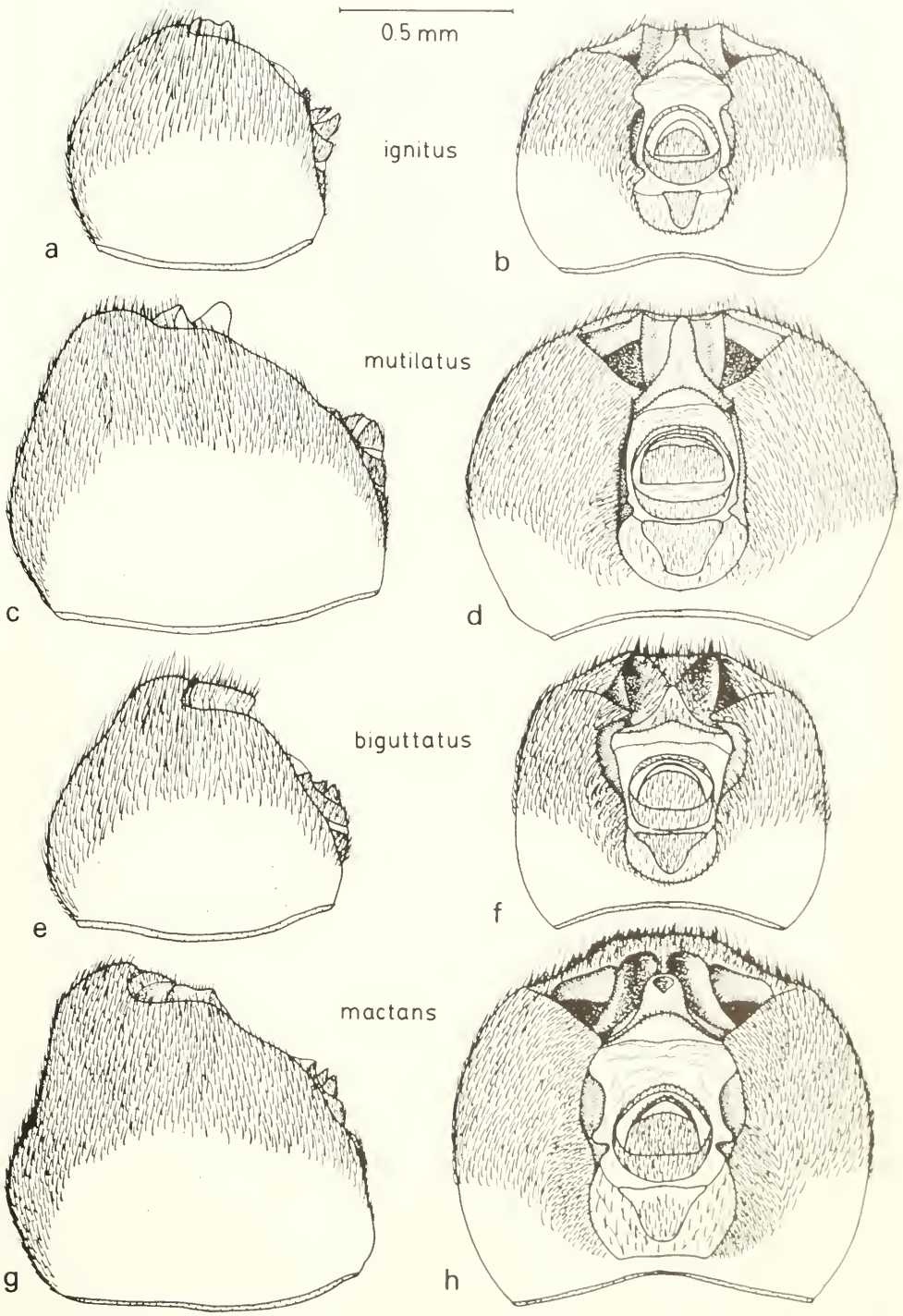


FIG. 75. *Melanerythrus* spp. a-h. Pygophore of named species: a, c, e, g, lateral view; b, d, f, h, dorsal view

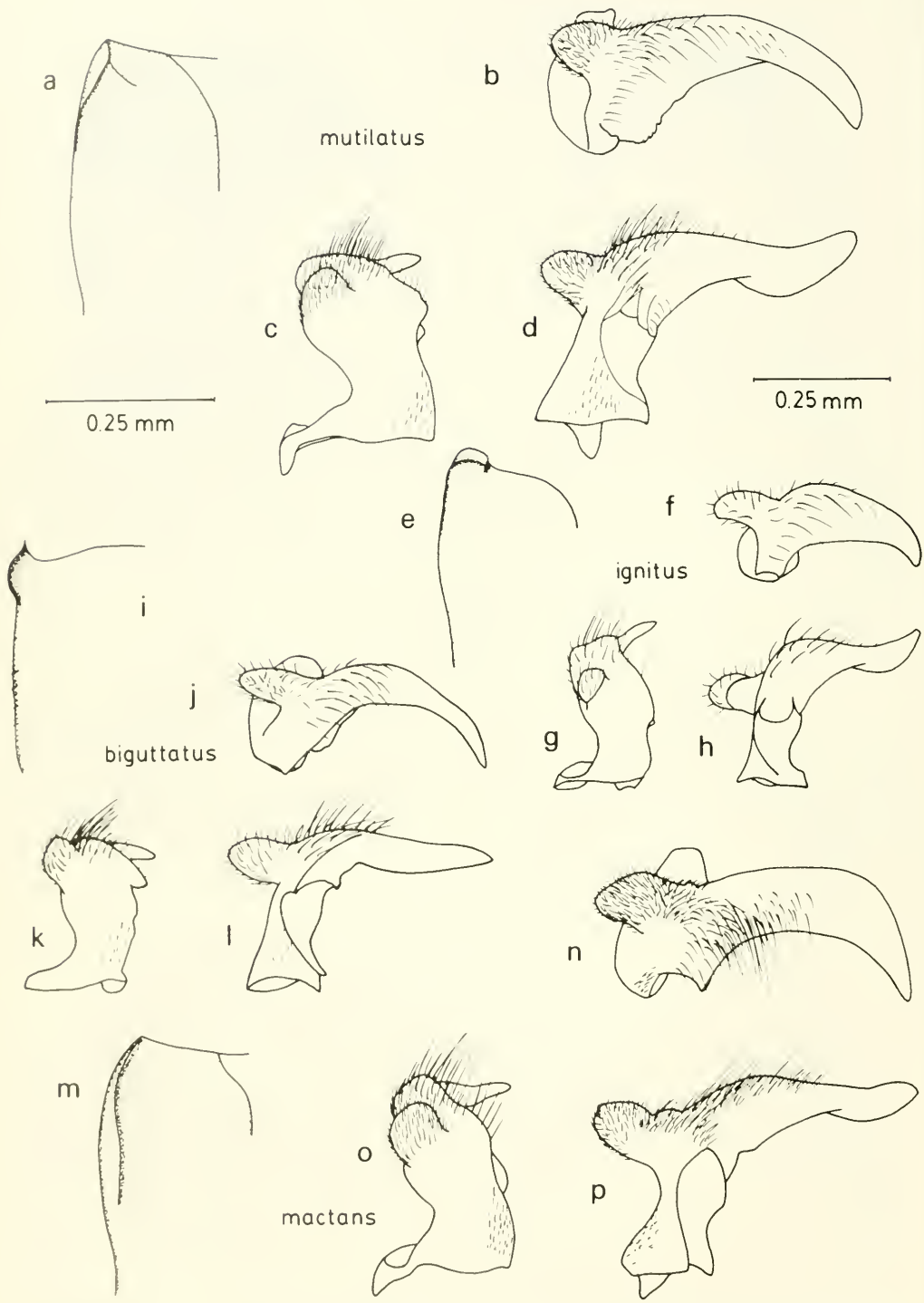


FIG. 76 *Melanerythrus* spp. a, e, i, m. Phallotheca of named species, dorsal view of left apex showing phallothecal process. b-d, f-h, j-l, n-p. Left clasper of named species: b, f, j, n, dorsal view; c, g, k, o, posterior view; d, h, l, p, interolateral view.

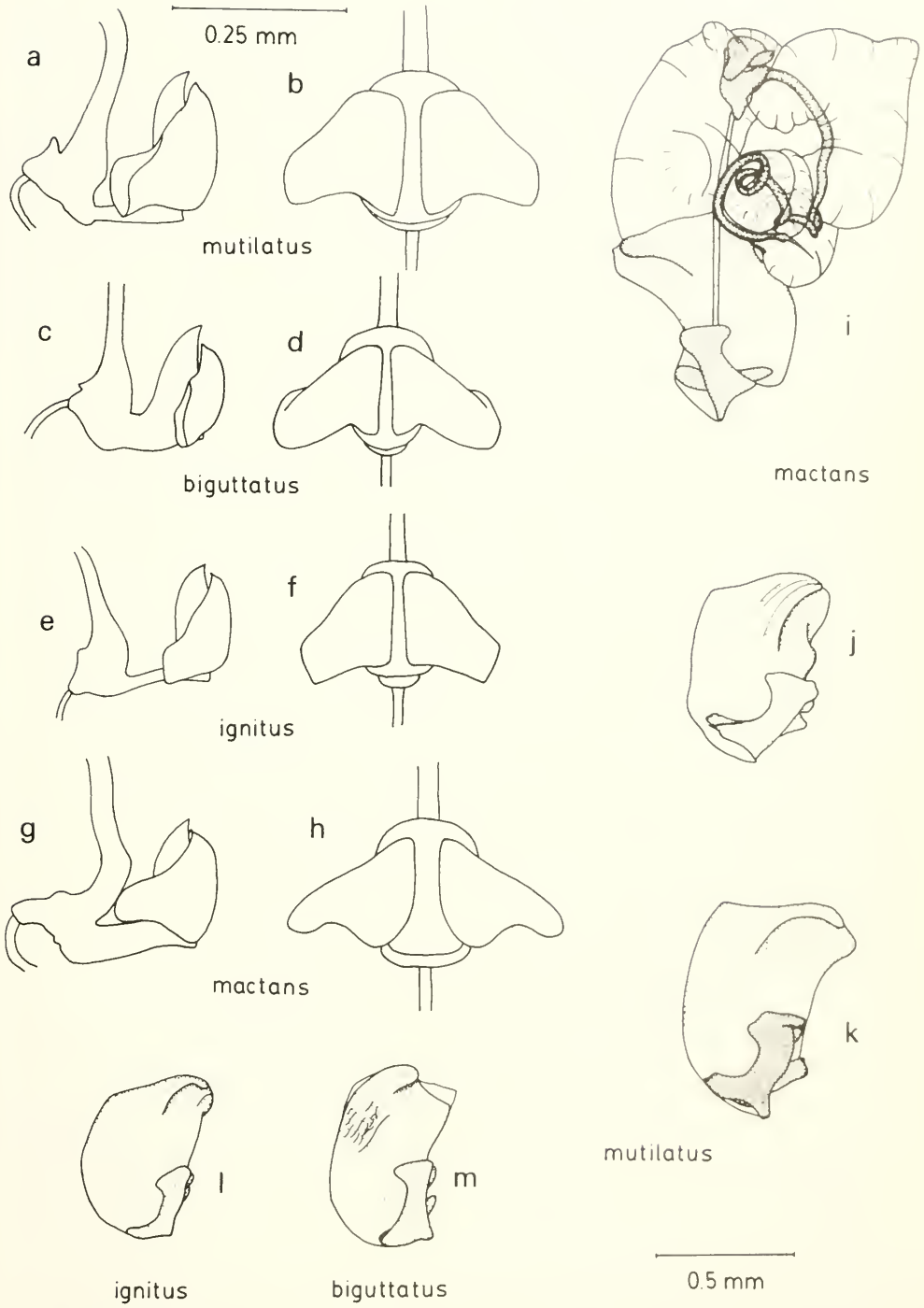


FIG. 77. *Melanerythrus* spp. a-h. Ejaculatory reservoir of named species: a, c, e, g, lateral view; b, d, f, h, dorsal view. i. *M. mactans* (Stål): inflated aedeagus, right lateral view. j-m. Phallotheca of named species, left lateral view.

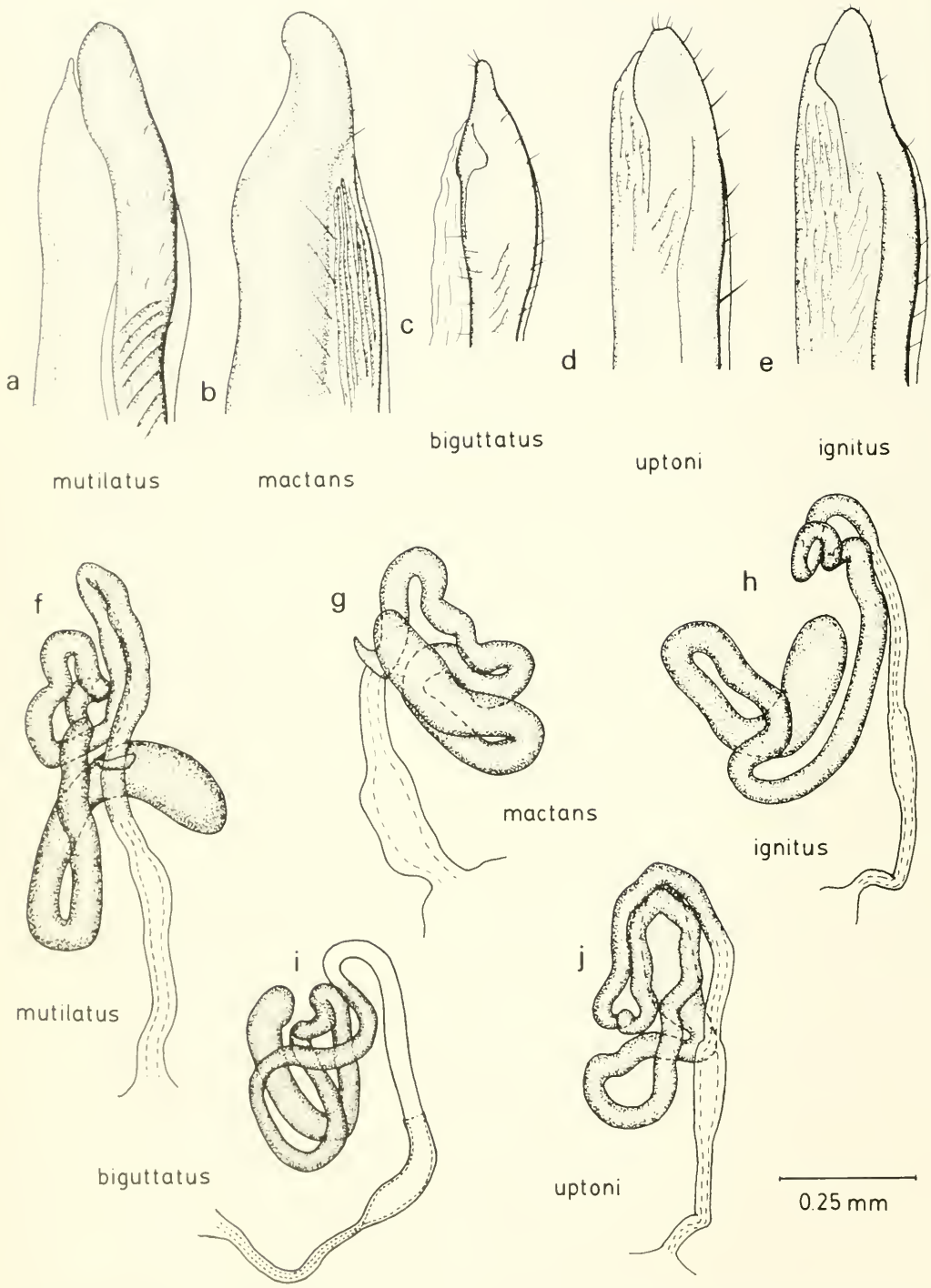


FIG. 78. *Melanerythrus* spp. a-e. Apex of left second valvula of named species, lateral view. f-h. Spermatheca of named species.

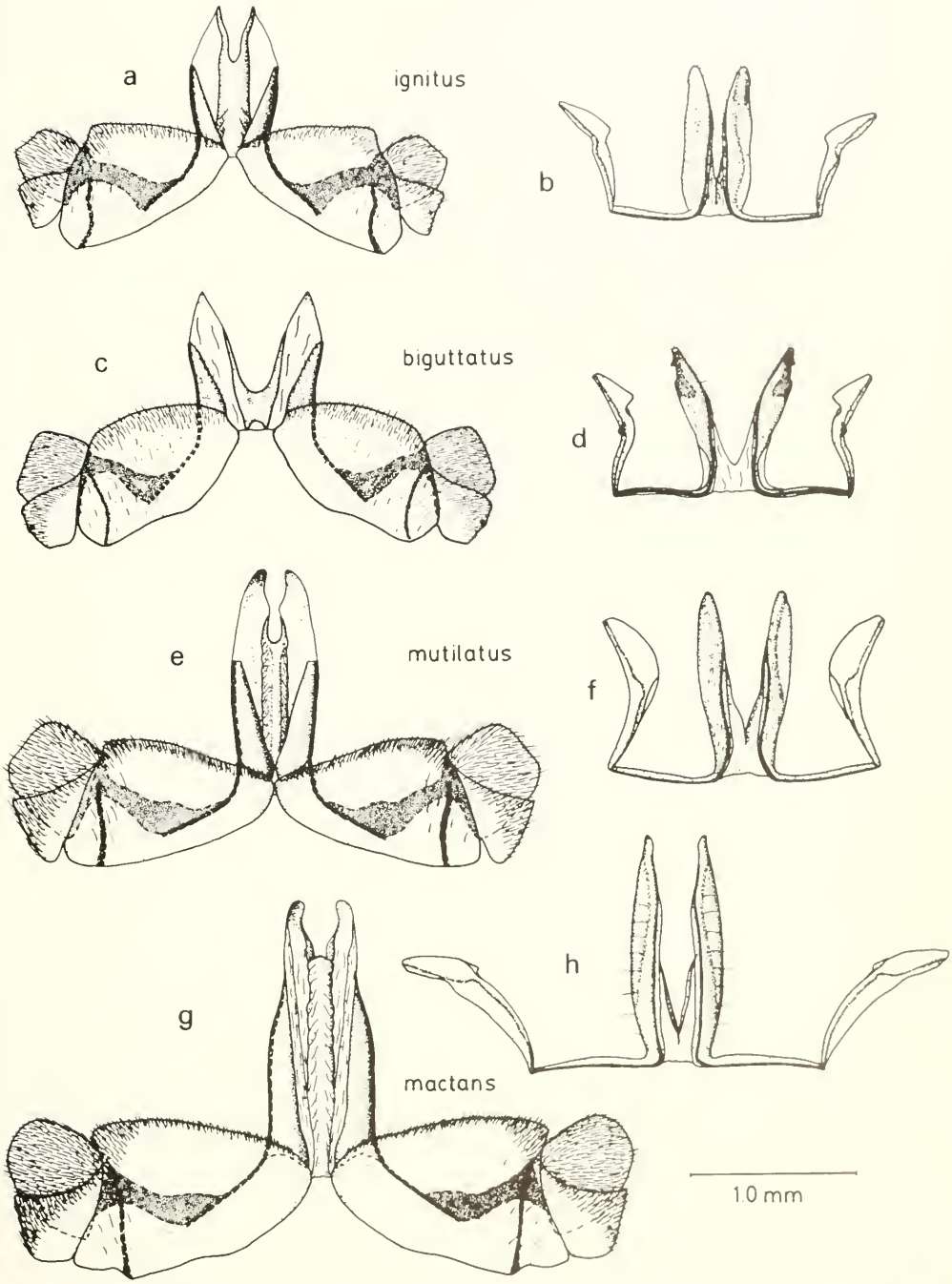


FIG. 79. *Melanerythrus* spp. a-h. Ovipositor of named species: a, c, e, g, first valve; b, d, f, h, second valve.

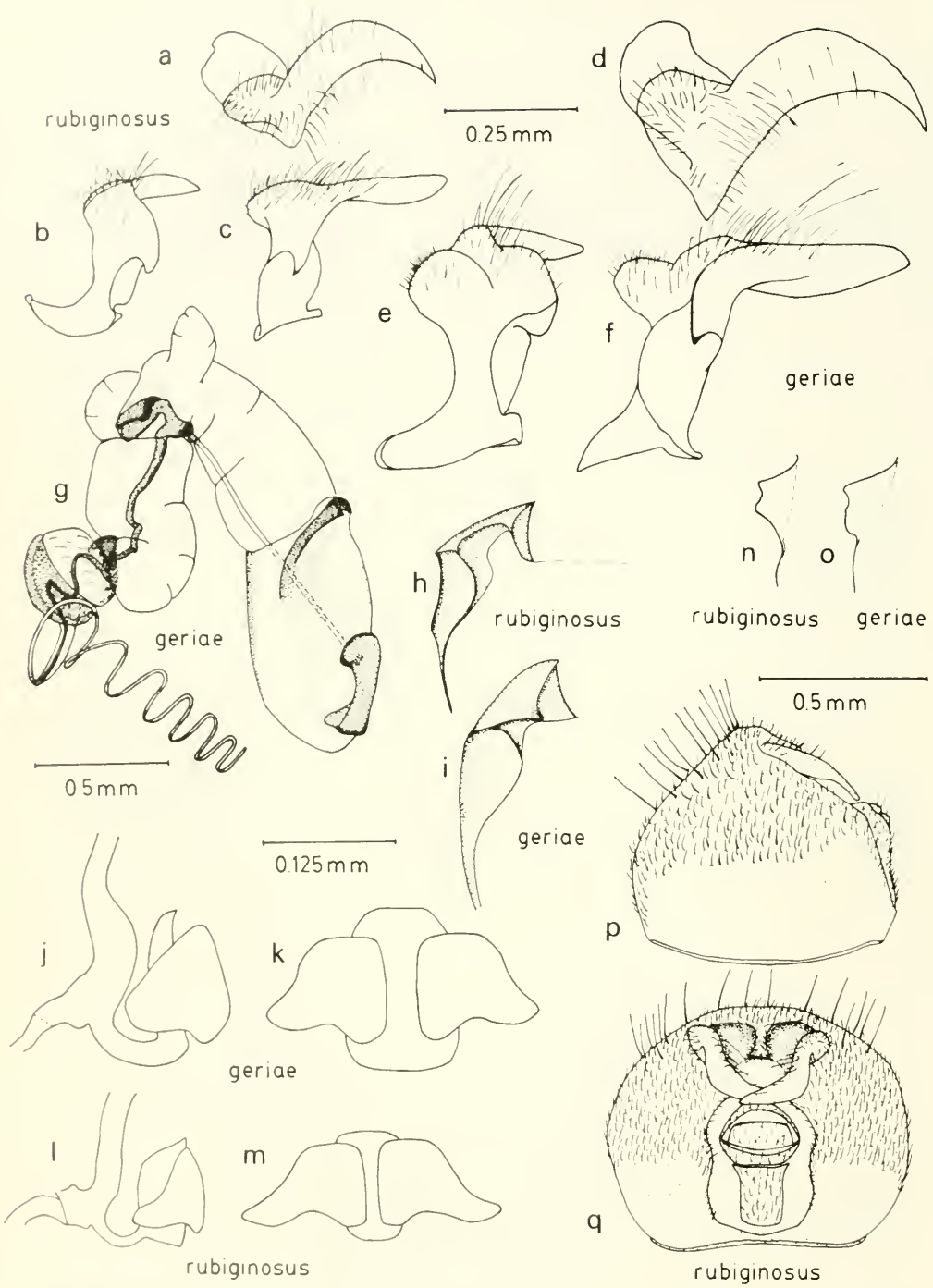


FIG. 80. *Melanotelus* spp. a-f. Left clasper of named species: a, d, dorsal view; b, e, posterior view; c, f, interolateral view. g. *M. geriae*, sp. nov., left lateral view of inflated aedeagus. h, i. Phallotheca of named species, dorsal view of left apex showing phallothecal process. j-m. Ejaculatory reservoir of named species: j, l, lateral view; k, m, dorsal view. g, h. Median projection of left margin of dorsal pygophore opening of named species. p, q. *M. rubiginosus* (Walker), pygophore: p, lateral view; q, dorsal view.

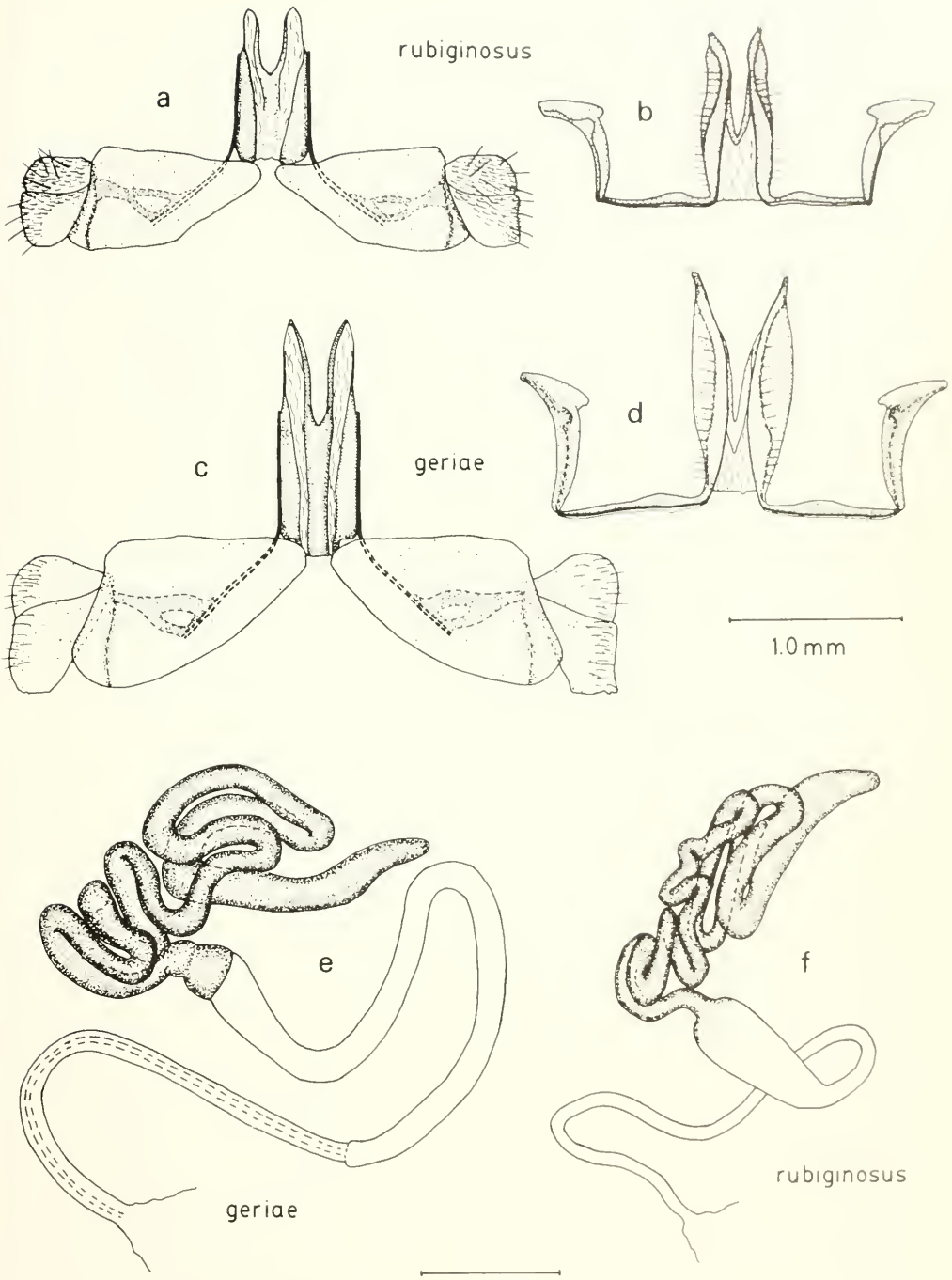


FIG. 81. *Melanotelus* spp. a-d. Ovipositor of named species: a, c, first valve; b, d, second valve. e, f. Spermatheca of named species.

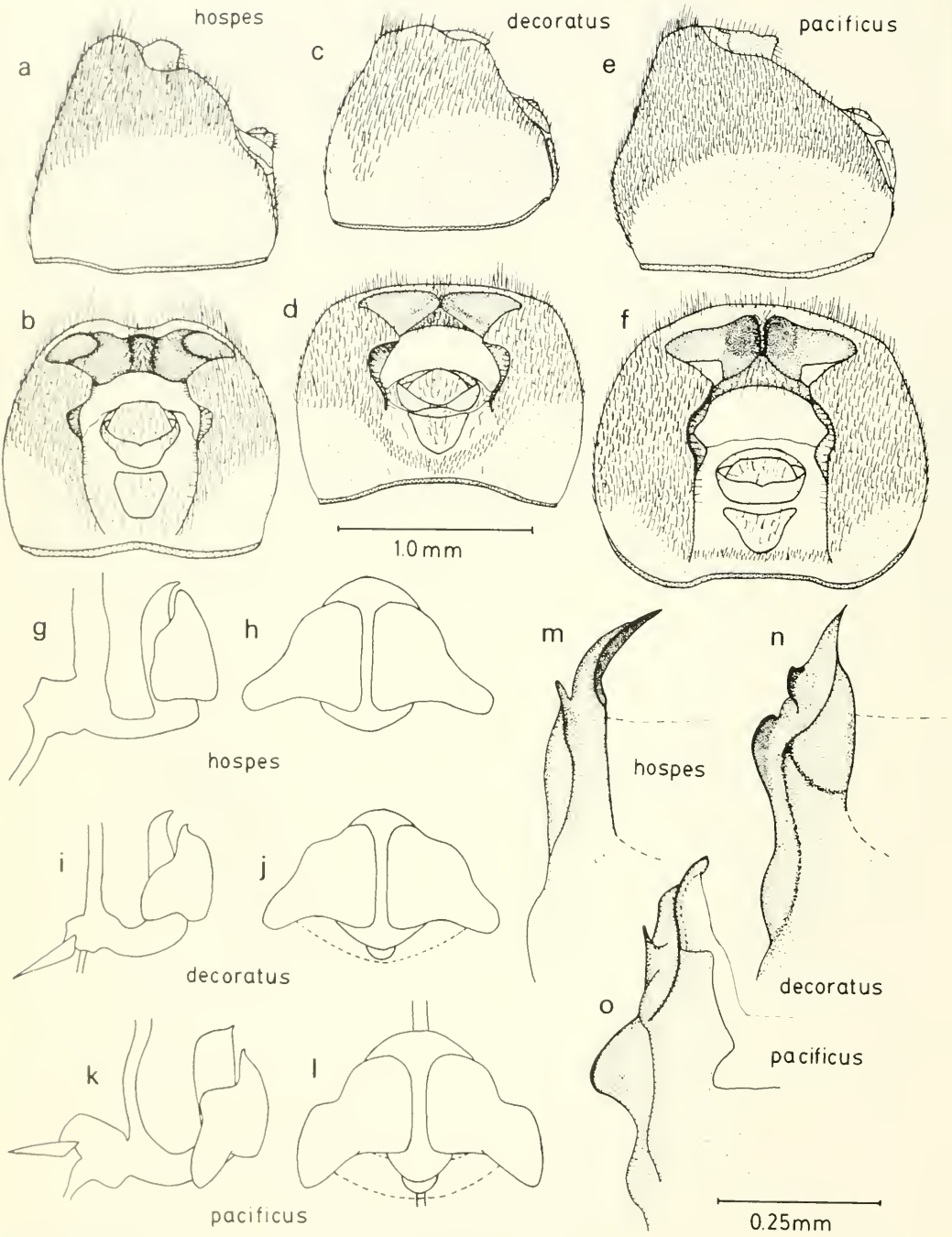


FIG. 82. *Spilosthetus* spp. a-f. Pygophore of named species: a, c, e, lateral view; b, d, f, dorsal view. g-l. Ejaculatory reservoir of named species: g, i, k, lateral view; h, j, l, dorsal view. m-o. Phallotheca of named species, dorsal view of left apex showing phallothecal process.

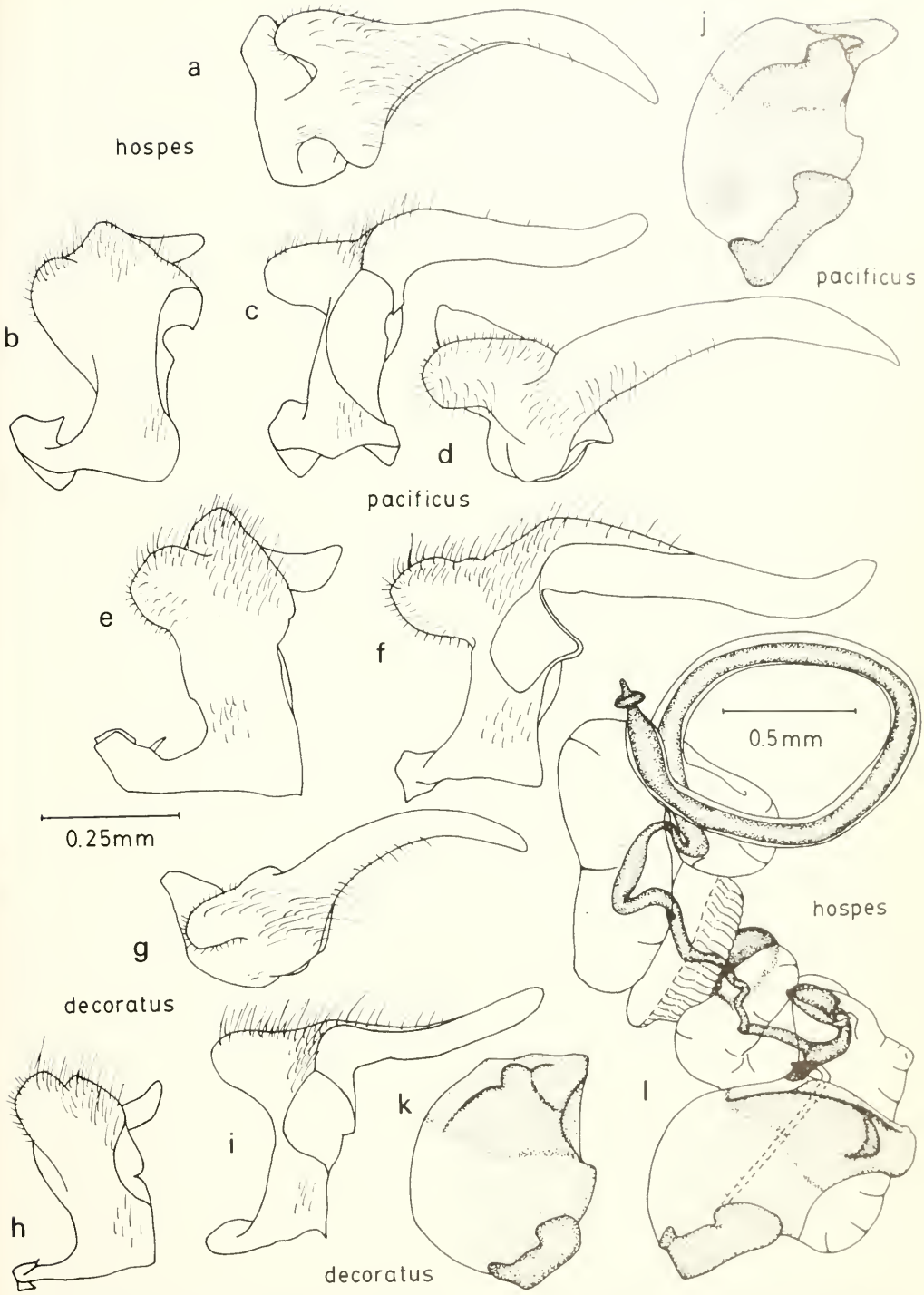


FIG. 83. *Spilostethus* spp. a-i. Left clasper of named species: a, d, g, dorsal view; b, e, h, posterior view; c, f, i, interolateral view. j, k. Phallotheca of named species, left lateral view. l. *S. hospes* (Fabricius), left lateral view of inflated aedeagus.

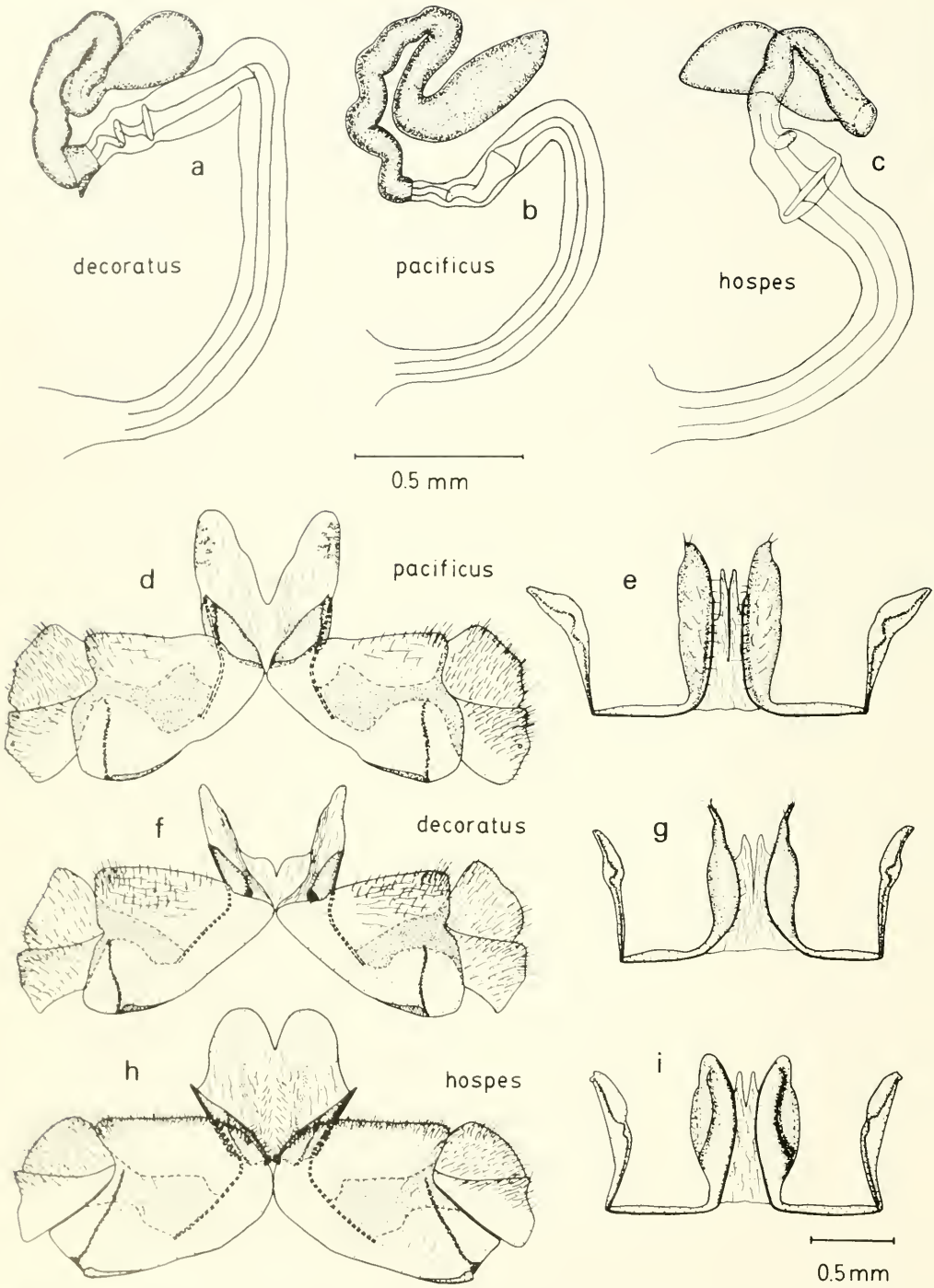


FIG. 84. *Stylostethus* spp. a-c. Spermatheca of named species. d-i. Ovipositor of named species: d, f, h, first valve; e, g, i, second valve.

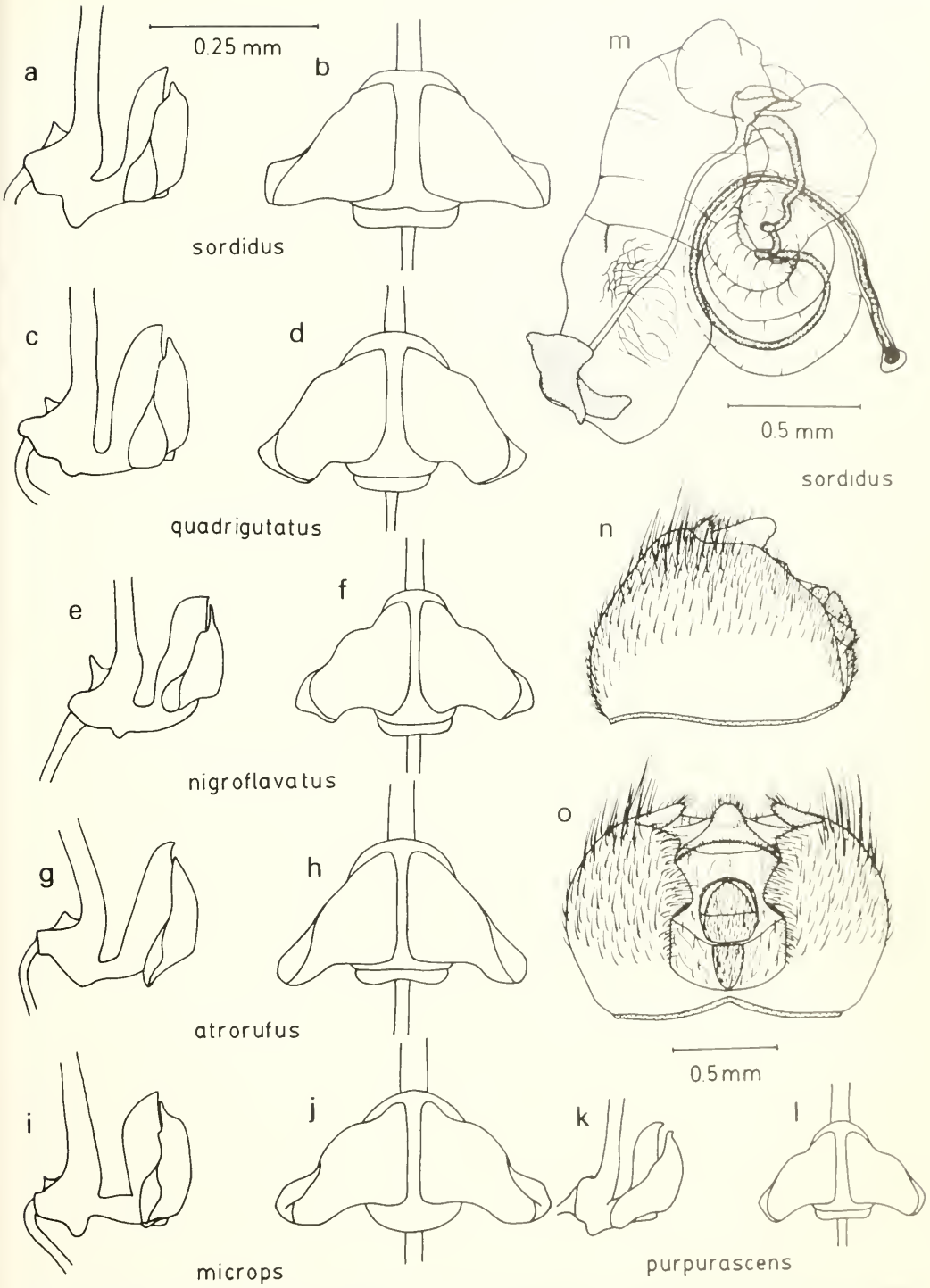


FIG. 85. *Oncopeltus* spp. a-l. Ejaculatory reservoir of named species: a, c, e, g, i, k, lateral view, b, d, f, h, j, l, dorsal view. m-o. *O. sordidus* (Dallas). m. Inflated aedeagus, right lateral view. n, o. Pygophore. n, lateral view, o, dorsal view.

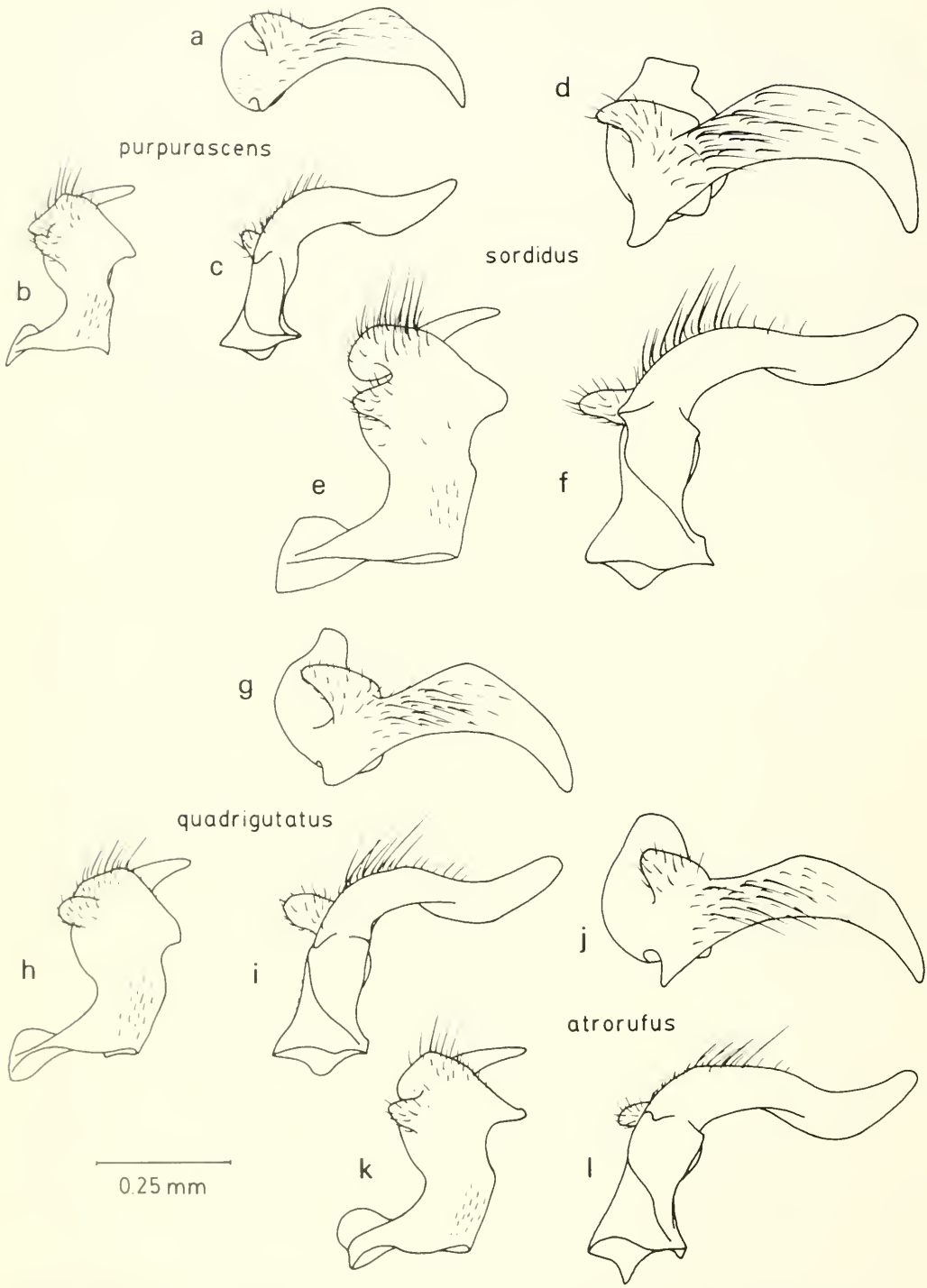


FIG. 86. *Oncopeltus* spp. a-l. Left clasper of named species: a, d, g, j, dorsal view; b, e, h, k, posterior view; c, f, i, l, interolateral view.

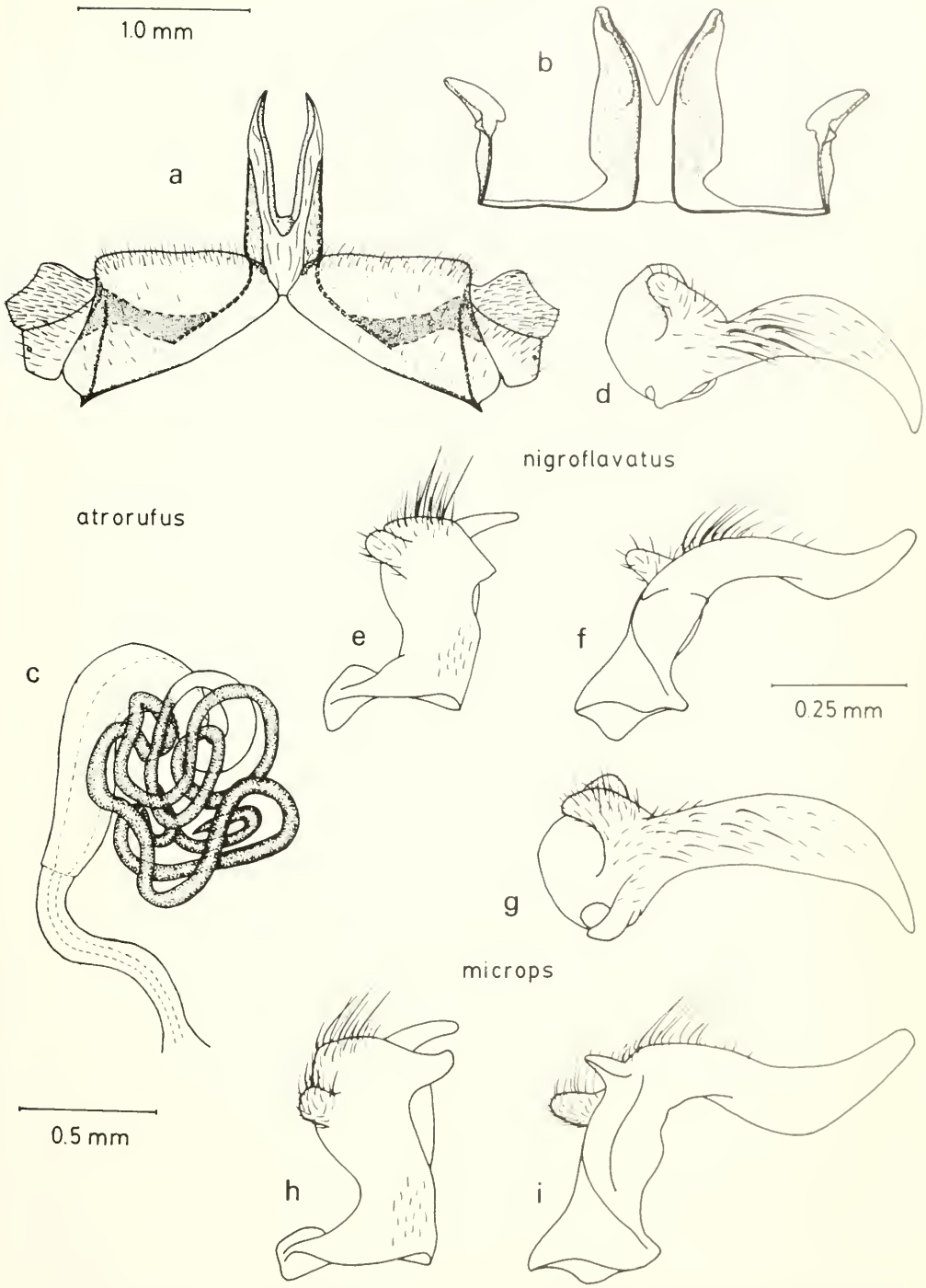


FIG. 87. *Oncopeltus* spp. a-c. *O. atrorufus* (Guérin). a, b. Ovipositor: a, first valve; b, second valve. c. Spermatheca. d-i. Left clasper of named species: d, g, dorsal view; e, h, posterior view; f, i, interolateral view.

2568 050

3 2044 093 3[illegible] 35

Date Due

~~MAR 31 1991~~